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ABSTRACT

The 52 papers presented reflect the diverse interests of the members of the National Association for Science, Technology and Society (NASTS). The first two papers deal with theoretical issues related to technological literacy (TL). Two papers discuss technology education at the elementary school level. Twelve papers cover various aspects of science-technology-society (STS) education at the middle and high school level, including project descriptions and ideas for addressing specific issues. Ten papers are on topics related to TL and STS at the college and university level. Some of these deal with TL as it relates to teacher education; others discuss the integration of technological issues into general education. The seven papers on general issues across educational levels take a broader perspective and examine the past and future of STS and TL programs. Technological literacy, writing, and the liberal arts is a clear area of interest, with seven papers focusing on this topic. Five papers deal with TL and minorities, four with TL and information services. The proceedings conclude with two papers on ethics, values, and technological literacy and one on the challenges facing STS education. (JB)

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Technological Literacy IV: Proceedings of the Fourth National Technological Literacy Conference, February 3-5, 1989

Arlington, VA

Edited by

Dennis W. Cheek

Leonard J. Waks

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INTRODUCTION

These proceedings from the Fourth National Technological Literacy Conference (TLC-IV), February 3-5, 1989, testify to the continuing interest and vitality of the movement for increased technological literacy for citizens of America and other nations of the world. With plans for TLC-V already in place, it is appropriate to reflect upon the growth and substance of this movement.

The first TLC was held in Baltimore, February 14-16, 1986. Thirty-eight papers by a total of 41 authors appeared in the 205 pages of proceedings [Bulletin of Science, Technology, & Society, 6, (2/3), 1986]. A major section sought to convey concepts, measures, and main issues involved in the idea of "technological literacy". Other sections were devoted to higher education, the K-12 community, technological literacy and minority learners, and educational technology. The second TLC on February 6-8, 1987 changed venue to the Washington, DC area. Increased attendance and participation led to a 366 page volume of conference proceedings with 71 authors contributing a total of 59 papers [Bulletin of Science, Technology & Society, 7 (1/2), 1987]. Sections on technological literacy concepts and frameworks, higher education, K-12 education, and educational technology remained as major areas of interest. A new area that emerged in the proceedings concerned women and technological literacy. Additionally, challenges and critiques to both STS and technological literacy signaled a healthy development of academic respectability and self-reflection.

The third TLC convened February 5-7, 1988 in the Washington, DC area with a further increase in attendance and a broadening of the areas of interest as shown by the 75 papers from a total of 91 authors for a mammoth 438 pages [Bulletin of Science, Technology & Society, 7 (5/6), 1987]. More than one author found humor in the publishing schedule of the Bulletin, whose date lagged a year behind the actual conference! Such is the fate of academic journals. Several areas from previous conferences were repeat organizers for the proceedings including higher education, K-12 education, technological literacy and women, and educational technology. The educational community sector had grown to such a degree that further subdivisions appeared as teacher training, adult/continuing education, and research. New areas that emerged were science, technology and development; science, technology, and democracy; the challenge of technology and society; and ethics, values, and religion.

Previous TLC proceedings were edited by the program chair, Dr. Leonard Waks, and published as special double issues of the Bulletin of Science, Technology & Society. Escalating printing costs made continued publication of the entire proceedings in this format prohibitively expensive. A decision was made to capitalize on the excellent dissemination capabilities of the ERIC system. Previous, out-of-print TLC proceedings had already been contributed to the ERIC system over the past year, so "publishing" in this format seemed appropriate to reach a wide audience of interested readers, researchers, and educators. We are pleased that 68 authors chose to contribute these 55 papers to this publishing endeavor. Several others chose to forego this manner of publication and directly submitted articles to journals. The number of papers this year is, therefore, not truly representative of the diversity or increase in size of the annual TLC.

TLC-IV witnessed the first annual meeting of the National Association for Science, Technology, and Society (NASTS). Two publications, the Bulletin of Science, Technology & Society and the NASTS News, serve as the official publications of the Association. The largest number of conference attendees to attend a TLC bore witness to the spreading interest in the TLC, especially from the educational community.

These proceedings reflect, in part, the diverse interests of the members of NASTS. A section on theoretical issues opens this set of papers. The major portion of these proceedings is devoted to educational issues with subdivisions of elementary, middle/high school, college, and general educational issues across levels. Technological literacy, writing, and the liberal arts emerges in this volume as a clear area of interest. Technological literacy and minorities continues as a recurrent focus of thought. The two remaining sections are also perennial areas of interest - technological literacy and information sciences, and ethics and values. Only four authors in these proceedings have papers in all previous TLC proceedings - testifying to the growing number and diversity of presenters.

At this junction in the unfolding development of the TLC and the larger movement toward technological literacy that it represents, it is important to reflect upon areas that are underrepresented at present within the movement as a whole. While there has been participation from several key individuals, it remains true that significant engagement between the technological literacy movement and the academic disciplines of the history, philosophy, and sociology of science and technology remain unrealized. The same lack of engagement can be found with the environmental community; museums and other non-school based teaching organizations; professional groups such as the American Medical Association, the American Association of Theological Schools, the National Technical Association, and various engineering societies; labor unions; and business and management organizations. Formal organizational participation from major groups within these areas remains an important goal. The Fifth TLC, for example, will witness the first formal participation of an engineering society (ASME). It is clear that both parties from such collaboration stand to benefit. The NASTS community will reap the benefits of the analytical frameworks, practitioner orientation, contextual knowledge, and large participation base the communities like these represent. These organizations stand to benefit from their association with NASTS due to the multidisciplinary perspectives that NASTS encourages as we all grapple with the complex interactions of science, technology, and society.

The nature of technological literacy, particularly in terms that can lead to educational efforts in the broadest possible sense, remains elusive despite the rhetoric of papers from all four conferences. There has been little research that has attempted the difficult but important task of finding out the kinds of technological literacy that are required by the everyday, working, twentieth century citizen. Numerous task forces, composed of persons who make their living in the fields of science and technology, have issued documents heralding new efforts at technological literacy for all. The degree to which such pronouncements should be taken seriously can only be addressed by research that looks at the current state of citizenry's technological literacy. Such assessment must move beyond "science-oriented" methods of assessment that ask a series of recall and theoretical application questions - whose results we hear so much of in national media. Tacit knowledge of science and technology as it relates to everyday functioning in the real world needs to be examined by quantitative and qualitative research techniques. Lessons and methodologies from research traditions in sociology, psychology, anthropology, the arts, literature, business, and education, need to be rigorously applied to the area of technological literacy. Deeper philosophical contemplation and broader use of historical analysis promises additional fruit.

The educational community needs to devote itself seriously to two major questions: "What exactly is STS education?" and "What is the relationship between STS education and technological literacy?". A cursory survey of currently marketed "STS material" from publishers and school districts demonstrates just how far from consensus the educational community stands regarding the nature of the STS innovation. While some argue that pinning the concept down is futile and counter-productive, a strong argument for some consensus is compelling. Current disparities in materials does not appear to reflect conscious and deep thought regarding the nature of STS and educational goals for STS education. Rather it reflects the nature of marketing with the slogans currently in vogue. Unless the STS educational community can grapply seriously and profoundly with this issue, publishers and other producers of materials will determine the nature of the innovation called "STS" with results that could have grave consequences for the future of STS education at K-12 levels across America.

Little attention has been given to such areas as cooperative learning, group decision-making, persuasive communication, environmental education, and pupils' conceptions of science, technology and society interactions and influence. We know very little, for example, about what conceptions pupils of varying ages bring with them to an STS learning activity. We do know, from studies in both science education and other educational areas, that what the learner brings with them to the learning task is the most significant variable in determining what is learned. Research like the pioneering efforts of Glen Aikenhead and his colleagues at the University of Saskachewan, needs to be expanded to fill the gaping holes in our knowledge about children's conceptions and construction of STS concepts and knowledge. The large body of research regarding environmental education and action needs to be culled and amplified to enable application of such findings to STS education. Curriculum making must move beyond the simple creation of materials to the actual "proof-in-the-pudding" evaluation to see if such materials really make a difference in students' knowledge as well as their attitudes - not just now but in their future. There is a desperate need for the launching and sustained funding of longitudinal studies of students in schools regarding STS education to collect the kinds of information needed to more appropriately tailor educational efforts in STS.

These are but a few of the major challenges as we look toward TLC-V in Washington, DC in February of 1990. While there can be deep satisfaction on the part of the technological literacy movement that its message is being heard with increasing clarity in appropriate quarters, such satisfaction must not lead to complacency. Much work remains to be done. These papers from this year's conference will serve a useful purpose if they stimulate greater research and educational activity and engender deeper reflections upon the nature and need for technological literacy for all.

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Producing a Technologically Literate Citizen:
A Curriculum Model

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The study of technology provides the means to develop problem solving and creative/critical thinking abilities, thus, producing a technologically literate citizen. This concept is paramount, since the purpose of education is to prepare children for the future in which they will live. With knowledge and technology doubling every two and a half years technology educators cannot any longer continue to prepare teachers or to educate children through traditional content methods. At this present rate of advance in knowledge and technology, it means that 90 percent of the knowledge and technology available to citizens shortly after 2000 has not yet been created (Hallett, 1987, p 48). The one thing guaranteed is that knowledge will continue to increase at a faster rate and that technology will be a dominant factor in this accelerated pace.

The current cluster curriculum model for the study of technology (manufacturing, construction, transportation, and communication) does not take into account the undeveloped or emerging technologies. It only reflects an industrial-based content study of technology, not technology _in toto_. Therefore, to prepare teachers or educate children through such a content-based study of technology is totally inappropriate for the 21st century citizen. What is needed is a holistic study of technology designed on a processes and concepts curriculum model. This provides a generic framework that provides the basis for students to solve problems.

The purpose of this article is to present a researched-based curriculum model for the study of technology that supports the development of skills and abilities in teachers and students in order to anticipate and solve tomorrow's problems. The model is designed to be used at any level. It can be used by students to solve a technological problems or to prepare teachers to teach the study of technology. The traditional four industrial cluster approach results in a static view of technology as subject matter. The model herewith proposes technology as a dynamic approach within which particular technologies and knowledge emerge and explicate to stimulate one to future thinking.

The curriculum model is based on the concept that by using this framework one increases their knowledge base with which to anticipate and solve problems. The same universal constants are used for all studies of technology. Over time one's becomes more familiar with using the curriculum model and increase their knowledge base, thus maximizing resources and minimizing restraints to the study of a technological problem. The result is a more technologically literate citizen.

Key Descriptors of Technology

First, the definition of technology must reflect a more holistic approach for the study of technology, not just an industrial focus. Not one, but many definitions must be used for this purpose. Current research has identified key descriptors of a definition of technology that provide the necessary components for such definitions. These are:

- Innovations
- Inventions
- Creativity
- Extension of human capabilities (physical, social, and intellectual)
- Process (change, individual, corporate, design, creative, and systematic)
- Extension of human potential
- Problem solving
- Purposeful human manipulation of the material world
- Closely linked to science but not simply applied science
- Body of knowledge
- Used to solve problems and create opportunities
- Played an important role in the emergence of *Homo sapiens*
- A system of tools, knowledge, and behaviors associated with the exploitation of environment
- Has social, economic, political, and environmental impacts (Barnes, 1987, p.182).

Organization

Parallel to the problem of describing and defining technology has been the confusion of how the technology curriculum should be organized and taught. This confusion is due, in part, to technology advancing at an exponential rate. It also is clouded by how all of this technological advancement and knowledge can be incorporated into the curriculum and be manageable. Some confusion is caused by the abstractness that technology tends to portray. There is also a debate as to whether technology should be organized and taught through a content or process approach.

To clear up this confusion, it is imperative that the study of technology be organized in a curriculum model of manageable components that are universal to a holistic study of technology and that are transferable from one technology to another. By doing this, one can logically analyze and organize any technological study by utilizing these universal constants of technology as major headings of the concepts to be studied. Therefore, the following curriculum model is suggested as a process approach to the study of technology and is highlighted in Figure 1. Problem solving is the technological method and it is the component that drives the curriculum. The curriculum is organized under three major components (a) systems of technology; (b) research and development; and (c) design and innovation. The content to be taught is analyzed and organized under six generic constants: (a) elements of technology; (b) restraints on technology; (c) resources of technology; (d) human values; (e) outcomes of technology; and (f) controls on technology.

[Insert Figure 1 about here]

Under these universal components any technology can be studied. This organizational structure also provides a system for transferring knowledge from the study of one technology to another. Thus, this method of transferable knowledge provides the basis for children to understand tomorrow's technologies and solve those problems associated with them. In the future, it will be the understanding and application of this type of organizational system that will ensure this.

The operation of this curriculum model for the study of technology is based on the premise that the method, elements, restraints, resources, human values, outcomes, and controls of technology are constants for the systems of technology, research and development, and design and innovation. The differentiation, then, is the variables that influence and interact with the organizer. This relationship is highlighted in Figure 2.

A variable or input (human values, restraints on technology, and resources of technology) enters the technological problem being studied at a point, with other inputs being added until all inputs have entered the system. This occurs through a systemic problem solving process and is analyzed through interaction with the elements of technology. The way inputs are managed through the problem solving process is based on prior knowledge and the recognition of these inputs through active experimentation, reflective observation, concrete experiences, and abstract conceptualization.

[Insert Figure 2 about here]

Problem Solving

Problem solving is the technological process (Black and Harrison, 1985, p. 3). Therefore, problem solving is the method that drives the curriculum. It is the holistic method that allows knowledge to be transferred from one technology to another. Problem solving, however, must be systemic in nature, not linear, if knowledge is to be successfully transferred from one technology to another.

It should be noted that problem solving and the scientific method are not the same and should not be confused or substituted for one another. The problem solving method produces the best possible solution to a problem based upon the best judgment and decision making at a given moment in time. The problem solution is not exact, since may other solutions could be effective in solving the problem. Conversely, the scientific method produces an exact solution to the problem.

This distinction can be further supported through Gradwell's comparison of science and technology (1988). He stated that the study of technology (a) is an open system; (b) utilizes deductive reasoning; (c) uses the design method; (d) is concerned with how things ought to be; and (e) results in discoveries which lead to theories. Conversely, science (a) is a closed system; (b) utilizes an analytical reasoning; (c) uses the scientific method; (d) is concerned with how things are; and (e) starts with a problem and is guided by a theory (p. 32).

In a similar fashion, Fisher (1986) identified the basic elements of technology education and science education when he compared the two subjects in the United Kingdom. Technology education (a) is project based; (b) involves controlling systems; (c) is broad based; (d) is a creative process related to human needs; (e) uses the design process;

(f) utilizes problem solving; and (g) is concerned with the purposeful use of human's knowledge, utilizing materials, energy, and natural phenomena. Unlike technology education, science education (a) has a scientific body of knowledge of knowledge; (b) utilizes knowledge derived from empirical evidence; (c) uses inductive reasoning; (d) tests validity objectively; (e) has a distinct methodology; and (f) utilizes the processes of categorization, classification, close observation, measurement, and prediction (p. 12).

The problem solving method used to process the inputs must be systemic. Where one enters and how one moves around in the problem solving process depends on how the inputs are recognized. The systemic problem solving process includes (a) identification of the problem; (b) brainstorming; (c) analysis; (d) information gathering; (e) design brief, (f) alternative solutions; (g) optimum solution; (h) communicating ideas; (i) planning and evaluation; (j) modeling; (k) testing; (l) modification; (m) final evaluation; (n) final report; (o) implementation of the solution; and (p) impacts of technology.

Curricular Organizers

To properly foster a broad-based study of technology through the problem solving process, the study must be organized by concepts or processes, instead of specific technologies. Therefore, based on Barnes' research (1987), the study of technology should be organized as (a) systems of technology; (b) research and development; and (c) design and innovation (p. 185). Subsumed within each curricular organizer are the values in technology and the awareness of implications and potential of technology. This curricular organization is student-centered, not teacher-centered. In this organization approach, students are given technological problems to solve, based on their abilities and needs. Students progress sequentially from systems of technology to research and development and capstone with design and innovation.

The systems of technology focuses on the interrelationships between the various technological systems; not just the industrial technologies of manufacturing, communication, construction, and transportation. It is a holistic approach that does not isolate the study of technology into a specific technology. It also provides an application of the other school disciplines through the common thread of technology.

It is the foundation course and the one in which all students enter. In the systems of technology students utilize the model outlined in Figure 2 to solve problems. At this stage the development of brainstorming techniques is crucial and the first concept to be taught. Design is heavily emphasized to develop creative and critical thinking skills and abilities. Students log all information and illustrations about the problem being studied in a portfolio. The portfolio in turn becomes a documentation of the student's thought process in solving the problem. Students also construct models and defend their solution.

Elementary students may study toys to learn about systems of technology. This can be done by giving students different toys which have visible moving parts. The students study and analyze the toys to identify the inputs, processes, outputs, and controls of the different systems within the toys.

Research and development focuses on students solving technological problems, through advanced applications of the various systems of technology. Like the systems of technology, research and development is a holistic and integrative approach. It utilizes the same model as used in the systems of technology. The research effort is student generated, with the teacher serving as a student advisor. As in systems of technology, students develop portfolio's construct prototypes, and defend their problem solution.

In research and development, middle school children can select an invention to study. The invention selected is not important. What is important is what lead to the invention being created, the processes used to develop the invention, its evolution, and impact on society. Students will utilize portfolios, models, seminars, and research reports throughout the study.

Design and innovation is the capstone phase of the organizational structure. It focuses on students brainstorming new concepts and ideas, then problem solving an implementable solution for their innovation. It allows students the opportunity to pull together what they have learned from systems of technology and research and development and apply it to a new concept or idea. This phase of the study of technology could be done through a corporate partnership. Students may select to develop a plotter, security system, energy saving device, and on and on. At the university level, design and innovation can be a capstone course to tie together what students have learned and how well they can apply it.

Curricular Constants

There, also, must be constants for these curricular organizers that ensure knowledge transfer. Therefore, six basic constants are applicable to the study of technology: (a) the elements of technology; (b) restraints on technology; (c) resources of technology; (d) human values; (e) outcomes of technology; and (f) controls on technology. These six constants are universal to all technologies. It should be noted that what varies are the inputs that impact on a technological problem and the degree to which they are handled in the problem solution.

Todd, McCrory, and Todd identified six elements of technology that are universal to the study of technology. These are (a) tools; (b) materials; (c) processes; (d) energy; (e) information; and (f) humans. Tools are any kind of device, machine, or instrument. Materials are used to build machines, which in turn use materials to make products. These are the basic ingredients of technology. Processes are sequences of operations that produce some result. Energy is concerned with the understanding of energy sources, forms, and conversion to change raw energy into a practical use. Information utilizes symbols and signals from which to construct communication and control. Humans use and interact with tools, machines, energy, materials, and information (1985).

The restraints on technology are concerned with those inputs that limit the maximum solution to a problem and its most successful implementation of a solution. In some cases, the technology is available to solve a problem, but the science is not yet developed. The converse can be true, as well. Sometimes the scientific knowledge is there, but the technological knowledge is not. To the solution of any technological problem there are six generic restraints on technology that must be considered: (a) laws of science; (b) technical information; (c) financial information; (d) limits of knowledge; (e) the specific purpose; and (f) personal and social capabilities.

The resources of technology are those inputs that include (a) concepts and methods of science; (b) concepts and methods of technology; (c) energy (d) sources of information; (e) human quantity and quality; and (f) personal creativity. It is the degree to which these resources of technology are accessed and applied that influences the solution to the problem being studied. They interact the elements of technology and human values and are limited by the restraints on technology.

The human values are those innate inputs that the individual or group bring to the problem being studied. These include: (a) prior knowledge; (b) ethics; (c) values; (d) morals; (e) culture; (f) and attitudes. It is the blending of these characteristics harmoniously within the individual or group solving the problem that leads to viable solutions to problems and successful implementations.

The outputs of technology are those items that result from the solution of a problem. These include: (a) human achievement; (b) awareness; (c) capability; (d) economic; (e) social; (f) cultural; (g) environmental; (h) personal; (i) exploration; (j) comfort; (k) discovery; (l) artifacts; (m) investigation; (n) knowledge; (o) leisure; and (p) human value.

The controls on technology deal with the results and consequences of technology. The results occur immediately upon implementation, while consequences develop over time. The implementation of a solution to a technological problem is controlled either through various impacts on the solution or cybernetically. Impacts that affect the solution include: (a) social; (b) economic; (c) cultural; (d) political; (e) personal; and (f) environmental. A cybernetic control includes those things that are: (a) planned; (b) unplanned; (c) desired; (d) undesired; (e) intended; and (f) unintended. The controls on technology are what ensure the wise and safe use of technology.

The degree to which the constants are utilized to solve problems depends on the amount of prior knowledge of the individual or group and the ability to access, manage, and control information. This also depends on the ability of the individual or group to recognize the information that encompasses a constant through active experimentation, reflective observation, concrete experiences, or abstract conceptualization. As one continues to use this curriculum model the resources of technology are maximized, while the restraints on technology are minimized. This incorporated with positive human values and a greater understanding the elements of technology provide a increase in knowledge transfer to future technological problems. The results in a more technological literate citizen.

Conclusion

The curriculum model of the study of technology presented offers an innovative approach to preparing children to become technologically literate to face the challenges of tomorrow's world and to solve the problems associated with that world. This approach allows for knowledge transfer through a universal system, problem solving. Likewise, this approach to the study of technology takes into account the unknown and/or changing future technologies. This approach is not delimiting, but is holistic in nature, and allows for the integration and application of other school disciplines.

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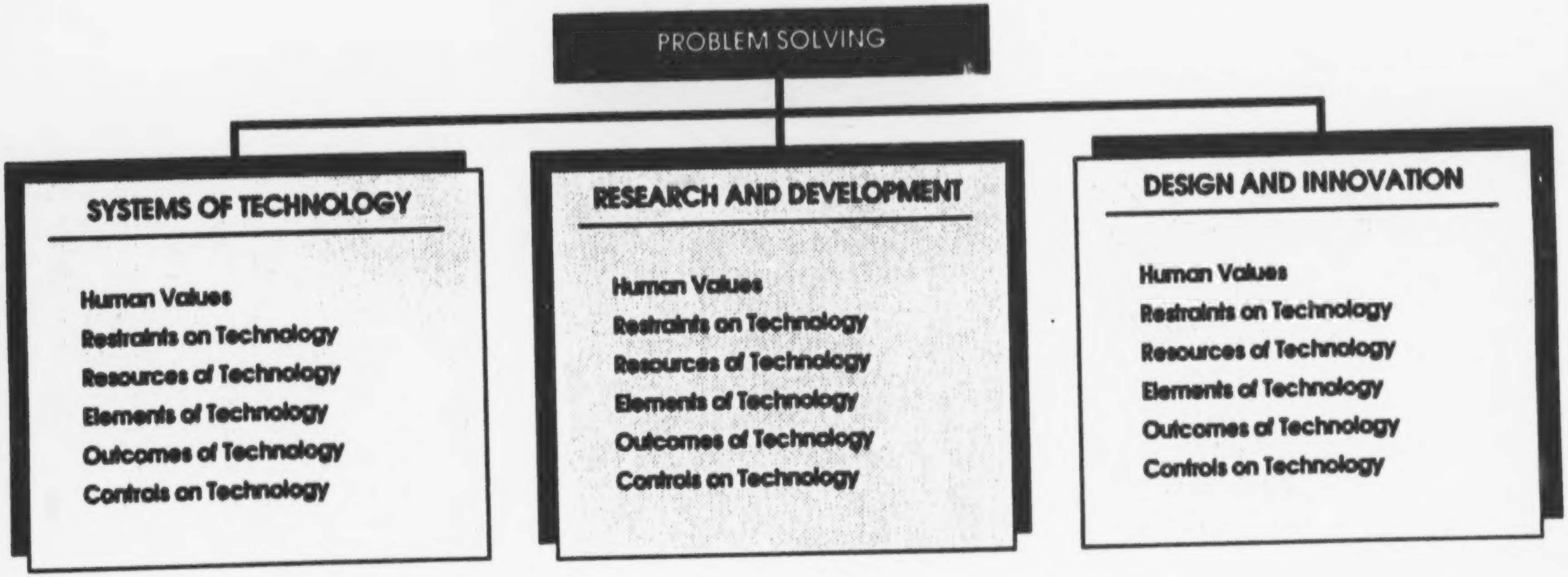

PROBLEM SOLVING

SYSTEMS OF TECHNOLOGY

- Human Values
- Restraints on Technology
- Resources of Technology
- Elements of Technology
- Outcomes of Technology
- Controls on Technology

RESEARCH AND DEVELOPMENT

- Human Values
- Restraints on Technology
- Resources of Technology
- Elements of Technology
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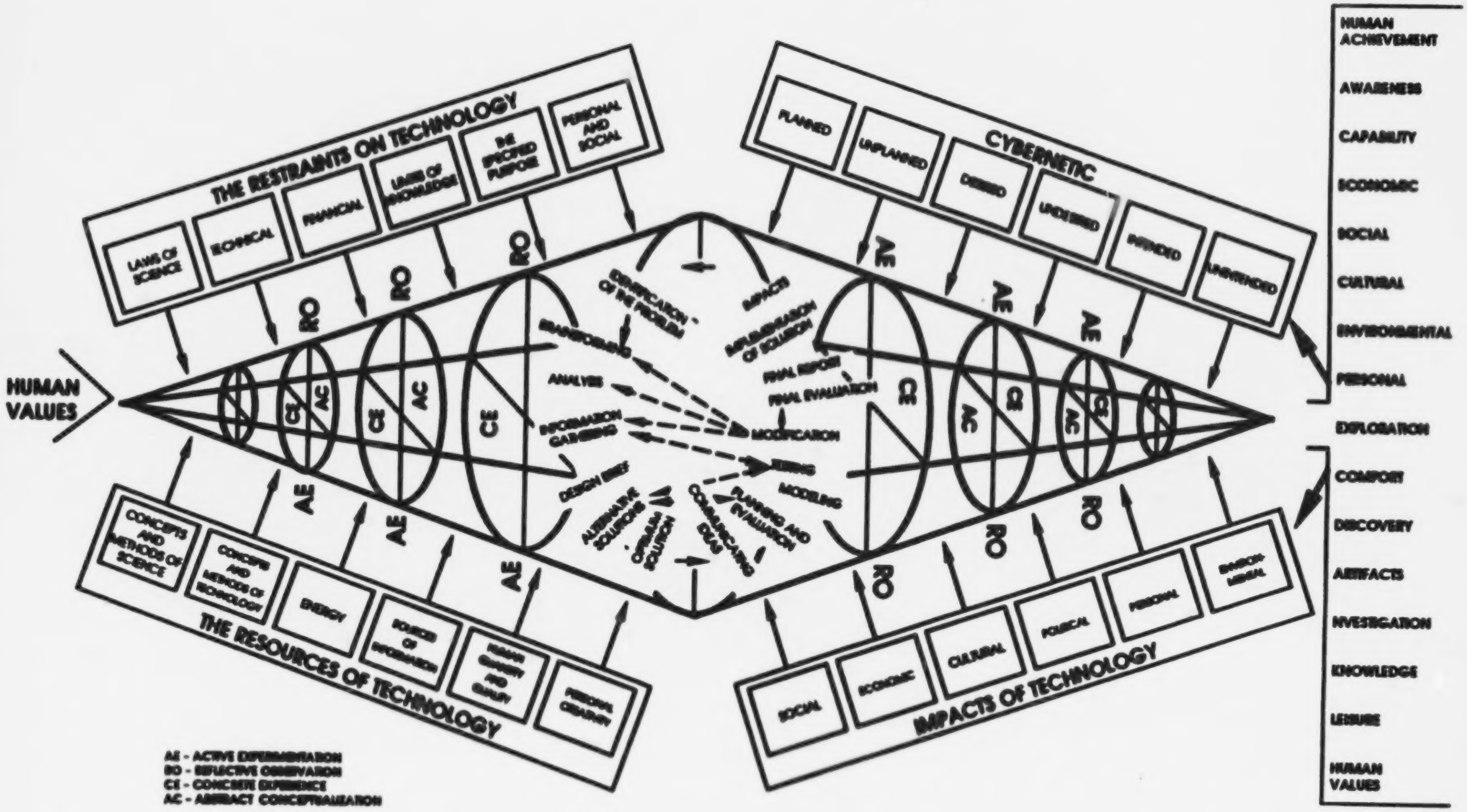
- Controls on Technology

DESIGN AND INNOVATION

- Human Values
- Restraints on Technology
- Resources of Technology
- Elements of Technology
- Outcomes of Technology
- Controls on Technology

FRAMEWORK OF TECHNOLOGY


HUMAN VALUES
THE RESTRAINTS ON TECHNOLOGY
LAWS OF SCIENCE
TECHNICAL
FINANCIAL
LAWS OF KNOWLEDGE
THE SPECIFIED PURPOSE
PERSONAL AND SOCIAL
CYBERNETIC
PLANNED
UNPLANNED
DESIRED
UNDESIRED
INTENDED
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RO
CE
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AE
IDENTIFICATION OF THE PROBLEM
BRAINSTORMING
ANALYSIS
INFORMATION GATHERING
DESIGN BRIEF
ALTERNATIVE SOLUTIONS
OPTIMUM SOLUTION
COMMUNICATING IDEAS
PLANNING AND EVALUATION
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FINAL EVALUATION
FINAL REPORT
IMPLEMENTATION OF SOLUTION
IMPACTS
CONCEPTS AND METHODS OF SCIENCE
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SOURCES OF INFORMATION
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THE RESOURCES OF TECHNOLOGY
SOCIAL
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HUMAN ACHIEVEMENT
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ENVIRONMENTAL
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EXPLORATION
COMFORT
DISCOVERY
ARTIFACTS
INVESTIGATION
KNOWLEDGE
LEISURE
HUMAN VALUES
AE - ACTIVE EXPERIMENTATION
RO - REFLECTIVE OBSERVATION
CE - CONCRETE EXPERIENCE
AC - ABSTRACT CONCEPTUALIZATION

Systemic Model of Problem Solving
For Technology Transfer

TECHNOLOGICAL POLITICS IN THE NUCLEAR AGE

John Byrne, Steven M. Hoffman and Cecilia Martinez

Introduction

For the last two centuries, Western expectations of a more just and equitable society have been predicated on scientific and technological advance. Utopians and futurists from Saint-Simon to Herman Kahn have argued that contemporary social progress derives (or should) from the application of science and technology to the solution of social problems and the removal of physical constraints. Through their application, an era of material abundance, social opportunity and democratic participation can be secured. In this view technological society tends toward greater political and economic equality, by on the one hand, providing the physical means of achieving democratic objectives (quoted in Ferguson, 1979, p.14); and, on the other, by *"universaliz[ing] all the beautiful and glorious results of industry and skill . . . [making] them a common possession of the people"* (Greeley, 1853, pp. 52-53).

Central to the fulfillment of the technological promise is an energy system capable of generating ever increasing amounts of cheap and widely available fuel. In a technological society, abundant energy represents the means to assure continued production of all other commodities. Thus, a principal task confronting society is the development of what has been referred to as an *"abundant energy machine"* (Byrne and Rich, 1986). For many contemporary writers, nuclear power is understood to be the technology capable of delivering limitless quantities of energy necessary for the continuation of human progress. Nuclear advocates regard this technology as possessing attributes uniquely suited to meeting the demands of progress. Their promotion of nuclear power is rooted in a belief which links technology and energy with abundance and social equality.

This paper evaluates the relationship between social equality and technological expansion with particular emphasis on the context of nuclear power development. The first part of the paper discusses the theory and ideology of technological equality. In the second part, we develop a critical analysis of this view, arguing that the modern process of technological development is embedded within social structures which, rather than offering the opportunity for increasing degrees of equality, tend to produce and reproduce political and economic inequality.

The Promise of Social Equality

The view that scientific and technological advance brings about a more equitable society rests upon three interrelated ideas: first, that science and technology furnish through systematic understanding and application the means to overcome scarcity; second, by ushering in material abundance, a process of social emancipation is initiated which replaces the dominions of nature and social privilege with universal rules of reason; and finally, science and technology open the way for the objectification of social order in which all merely political and economic differences among social groups are (or can be) dissolved and replaced by rational equitability. These themes of abundance, emancipation and objectivity form a political vision, compelling to the modern mind, of scientifically and technologically established social equality.

At least since the 18th century, Western technology and science have been associated with the promise of abundance. The industrial revolution in the U.S. and Europe seemed to confirm the capacity of new technical methods and modes of thinking to yield a world of plenty. Expansion in the types and numbers of goods produced was beyond anything experienced before in the West, encouraging the idea that *"technological development progressed not on an arithmetic scale . . . but that the process was geometric or even logarithmic in growth"* (Pursell and Kranzberg, 1967, p.3). In the face of rapid and widespread development, traditional norms of self-sufficiency, balance and stability lost their meaning and were replaced by ideals of growth and change (Kumar, 1978). Western societies put their faith in the transformative power of science and technology and seemed to reap rewards in nearly every sector of life: *"technological developments... increased man's control over his environment, ministered to his animal needs and creature comforts, rescued him from the ever-present fear of starvation, increased his mobility, lengthened his lifespan, and, in general, made work easier and life more comfortable"* (Kranzberg, 1973, p.62). Continued social support of science and technology would produce the level of affluence necessary to resolve the most vexing problems of Western civilization: *"poverty would be abolished; technology's benefits would spread worldwide to do away with misery and insecurity and hence with class and international warfare"* (Kranzberg, 1973,p.63).

The abundance realized during industrialization, and the promise of still greater material growth, created a new optimism about the social condition and possibility. Science and technology seemed to offer the prospect for emancipation of the human body and spirit. By the close of the 19th century, science and technology had released human beings from *"the drudgery of threshing wheat, digging dirt, carrying water, breaking rocks, sawing wood, washing clothes, and, indoors, spinning and weaving and sewing"* (Ferguson, 1979, p.16). Society was now able to assume the role forecast by Descartes: *"instead of the speculative philosophy now taught in the schools, "* we can by *"knowing the nature and behavior of fire, water, air, stars, the heavens, and all the other bodies which surround us... make ourselves masters and possessors of nature"* (1956, p.40). In this master role, not only was the human frame disburdened, but the human imagination freed as well (Mishan, 1971, p.4):

> *One has only to think with sublime credulity of the opportunities to be opened to us . . . universal adult education, free art and entertainment, frequent visits to the moon, a domesticated robot in every home and, therefore, woman forever freed from drudgery; for the common man, a lifetime of leisure to pursue culture and pleasure (or, rather, to absorb these from the TV screen); for the scientists . . . increasingly powerful and ingenious computers so that we may have yet more time for culture and pleasure and scientific discovery.*

More than abundance, science and technology are conceived in the West to have emancipated the individual and society from destiny. Neither nature nor social privilege govern, at least rightfully, the human potential. In the modern era, it is possible to choose the future guided only by the objective principles of science and the logic of technical application. In this respect, we are poised to implement Francis Bacon's ideal of a New Atlantis in which dominion issues not from force or scarcity, but from understanding.

To take advantage of this opportunity, traditional Western political organization must be revised to reflect the social realities wrought by science and technology. Specifically, political forms and values must undergo objectification so that they conform with scientific and technological reason. A 1978 essay by Daniel Boorstin provides a helpful illustration of the needed technicization of Western political life. In the piece, Boorstin proposes a special political term for Western industrial society -- a "Republic of Technology." This republic is sharply differentiated from earlier political forms in the West which, he argues, were governed by tradition and in which "the most valued works were the oldest." In the new republic, the highest social value is reserved for the most recent; the future, rather than the past, "binds" society together. Boorstin traces this value reorientation in part to modern science and the ideal of progress resonant in its operations. Attributing the observation to mathematician David Hilbert, Boorstin notes that the contribution of a scientific work is *"measured by the number of previous publications it makes superfluous to read"* (1978, p. 4). Similarly, this value reorientation reflects the process of "creative destruction" (Schumpeter, 1955) characteristic of technological innovation in which *"old objects simply become second hand"* (Boorstin, 1978, p.4). In the technological era, societies are distinguished *"not by their heritage or their stock of monuments (what was once called their civilization) but by their pace of change"* (Boorstin, 1978, p.4-5).

Scientific technological ideals of progress embody a social principle of obsolescence. Prior political history is rendered obsolete by the successes of science and technology, allowing us to phase out traditional political forms and values. Buckminster Fuller may have overstated the point when he remarked (Fuller, 1977, p.141):

> *Take away all the inventions from humanity and within six months half of humanity will die of starvation and disease. Take away all the politicians and all political ideologies and leave all the inventions in operation and more will eat and prosper than now while racing on to take care of 100% of humanity.*

But the general principle is widely accepted in the Republic of Technology that scientific reason and technological application are usually superior to rule by political interest. And this applies not only to our political past: much of the present social order will eventually need to be abandoned as well. As Boorstin observes, technological progress depends upon *"developing the need for the unnecessary; wants derive, not from "human nature . . . or century - old yearnings,"* but from *"technology itself"* (1978, p. 9). Obsolescence is an integral and necessary part of scientific technological change. It is the social parallel of our commitment to scientifically and technologically furnished material abundance and social emancipation.

This gives to science and technology a special role of defining what is valuable, and what is not, over time. In this respect, both have normative rather than simply instrumental status in the republic. Public values and interests are fashioned within an environment produced by technology and science and are subject to change, even veto, by the abundance-obsolescence cycle of technical development. Because social options are routinely evaluated within a framework of scientific and technological feasibility, Langdon Winner has suggested that *"the role of technological circumstances in the modern era does in fact supplant other ways of building, maintaining, choosing, acting and enforcing, which are more commonly considered political"* (1977, p.237).

With the technicization of political life, the Republic of Technology claims its most distinctive possibility -- the attainment of democratic equality. Science and technology have been the "great levelers" in the modern era, bringing to everyone a common material experience (Boorstin, 1978, p.3):

> *. . .developed in eighteenth-century England and spread over Europe and the New World. . . power-driven technology and mass production meant large-scale imports and exports -- goods carried everywhere in steam-driven freighters, in railroad freight cars, on trancontinental railway systems. The ways of daily life, the carriages in which people rode, the foods they ate, the pots and pans in their kitchens, the clothes they wore, the nails that held together their houses, the glass for their windows -- all these and thousands of other daily trivia became more alike than they had ever been before. The weapons and tools -- the rifles and pistols, the screws and wrenches, the shovels and picks -- had a new uniformity . .*

Eugene Ferguson offers a similar view of the democratization of ordinary life brought about by modern science and technology (1979, p. 16):

> *The democratic ideal of American technology shone brightly, too, as countless low-priced pictures, books, lamps, rugs, chairs, cookstoves, and musical instruments served to lift hearts and reduce boredom and despair. The mail-order catalogs that appeared at the end of the 19th century epitomize the democratization of the amenities that has marked the rise of American technology. Rail, if you will, at the decline of taste; but look first at the real alternatives of bare walls, dirt floors, and minds untouched by the imaginative works of writers, poets, painters, and sculptors.*

The democratizing impact of science and technology continues in the present. In the contemporary Republic of Technology, *"anyone can be a citizen"* precisely because science and technology are *"ruthlessly egalitarian"*: in contrast to the pre-technological/ pre-scientific Western ideal of democracy -- the "Republic of Letters" -- in which citizenship was functionally reserved for the select few *"who shared knowledge,"* the modern-day resident *"need not be learned, or even literate, to share the fruits of technology"* since *"Anybody can get the message from a television screen"* (Boorstin, 1978, pp. 3, 5 and 10). Kranzberg and Pursell present the argument with less flair, but with the same conclusion (1967, p.702):

> *Technology made possible modern industrial society, which provided the conditions for contemporary democracy. We can see the democratizing force of technology at work in many different ways. For example, the machine is color-blind: it does not care whether the hand that operates it is black, yellow, or white. Proof of this democratic impact of advancing technologies can be seen in the progress toward integration in the southern United States. The development of a new industrial South . . . is slowly but inexorably bringing an end to inequality. This situation is not peculiar to the United States; the demands of a modern industrialized society in India have breached the caste system in many places.*

The last point is echoed throughout Western literature on science and technology. Jerome Wiesner, past president of the Massachusetts Institute of Technology, has observed (quoted in Borgmann, 1984, p. 38):

> *More than any nation in the world, the United States has the opportunity to lead mankind toward a life of greater fulfillment. This opportunity is based on benefits from our continuing advances in science and technology. It is significant that people everywhere look to the United States to provide the science and technology which they need as they, too, seek to improve their condition.*

And Boorstin suggests that *"we see the experience of all peoples converging,"* and even proposes that *"while it took centuries or even millennia to build a civilization, the transformation of an 'underdeveloped' nation can be accomplished in mere decades"* with the adroit use of science and technology (1978, p.5).

In sum, scientific and technological advance is conceived by many strands of Western thought to furnish society with an infrastructure of material abundance that frees the human body and spirit to choose and enjoy a self-determined future. With prudent use of scientific reason and adherence to technical principles, democratic equality can be realized, a goal that, until now, has eluded civilization. Ours is an era of *"opportunities of opportunity"* (Boorstin, 1978, p.12).

The Nuclear Idea of Equality

The norms and aspirations of technological society are nowhere more evident than in the area of energy production and development. Since the days of early industrialization when coal and steam were first harnessed for power, energy consumption has been regarded as an essential facet of human prosperity. Underlying the ideology of technological abundance is the belief that the advance of civilization is fundamentally dependent upon an ever increasing supply of power for the production of material goods. George Basalla has labeled this relation the *"energy-civilization"* equation. He argues that each newly developed source of energy has been vested with utopian powers, *"promising a golden land of the future"* (1982, p.28), while simultaneously forewarning of the impending doom awaiting civilizations resigned to lower rates of energy use (Basalla, 1980, p.39, 40):

> *. . . tractors paralyzed in the fields, abandoned automobiles rusting on weed-choking freeways, factories as quiet as tombs, and haggard descendants facing a life of everlasting drudgery . . . As less energy is available per capita the nation is thought to lose its standing among the world's civilizations .*

Since its inception, nuclear energy has been promoted as the technology of energy abundance. Even before the first prototype nuclear power plant was in operation, Alvin Weinberg, a chief architect of the U.S. nuclear program, celebrated *"the unborn technology"* of atomic energy as the *solution to one of mankind's profoundest shortages"* (1956, p. 299). Exuberance for nuclear power among its scientific proponents has not been dampened in the thirty years since birth. According to Harold M. Agnew, former director of the Los Alamos National Laboratory, *"nuclear is the only nonfossil fuel energy source that will be available to us in sufficient amounts to supply our current civilization and to fuel progress for the foreseeable future"* (1983, p. 1). Even this evaluation may understate the importance of nuclear power. As David Lilienthal, the first chairman of the U.S. Atomic Energy commission, has observed (1980, p. 10):

> *Energy is more than an impersonal statistic to be bandied about by computers and theoreticians. Energy is part of a historic process, a substitute for the labor of human beings. As human aspirations develop, so does the demand for and use of energy grow and develop. This is the basic lesson of history . . . For many other peoples [in the non-industrialized world] energy sources are scarce, and therefore their living standards are low. Their need for more energy is desperate. Inevitably they look to us and to other highly industrialized nations, needing to use our technology to develop more abundant supplies of energy.*

It is perhaps only in this context that one could describe the harnessing of the most destructive force known to humanity as heralding a new age where life would acquire *"a gentler, more abundant aspect"* (Weinberg, 1956: 302).

The significance of nuclear power cannot be assessed solely in terms of its instrumental value or effectiveness. Through the discovery of the fundamental secrets of the universe, the scientific and technological community claims to possess the means to liberate humankind from the scarcities of nature, not by further exploitation or numerical increase, but through the use of scientific and technical knowledge. In this sense, nuclear power marks our passage from a social order limited by scarcity and the conflicts to which it gave rise, to a new Republic of Technology ruled not by political or military domination, but by scientific reason. In the nuclear vision, *"social and political tradition become obsolete with the full flowering of the Scientific Era simply because all of the traditional doctrines were conceived in an economic and technolgical era which bears little relation to the age of abundance"* (Weinberg, 1956, p. 302).

But if the past is obsolete, the future is uncertain until and unless society carries out the changes it must to realize the nuclear promise. Science and technology have provided the opportunity, but if the vision of nuclear abundance and emancipation is to be fulfilled, an abiding social commitment is needed to make nuclear power work. Presently, what stands in the way of nuclear power -- and progress --- has little if anything to do with practical or technical considerations, according to its advocates. With the appropriate knowledge and method at hand, *"every large-scale scientific or technical problem is soluble,"* or will be, in due course (Weinberg, 1956, p. 310).

But as the accumulation of scientific knowledge continues to foster technological change through new discoveries, social institutions too often fail to keep pace. According to some, nuclear power has been saddled with the problem of social inertia almost from the outset. Thus, Lilienthal warned in 1949 that unless institutional changes were made, *"the atomic adventure may be stifled in the throes of politics, of routine, of sluggishness and apathy"* (1949, p. 146). For the scientifically informed, this is unacceptable; failure to respond to the new challenge is tantamount to social retrogression (Lilienthal, 1949, pp. 145 and 147-148):

> *Atomic energy is a force as fundamental to life as the force of the sun, the force of gravity, the forces of magnetism. It is an unfolding of new knowledge that goes to the very heart of all physical things. Perhaps the greatest single opportunity for new fundamental knowledge about the nature of the physical world lies in the development of atomic energy. Within the atomic nucleus are those deep forces, so terribly destructive if used for warfare, so beneficent if used to search out the cause and cure of disease, so almost magical in their ability to pierce the veil of life's secrets. . . . For the citizens of the world's leading democracy to be in the dark as to the nature of the fundamental structure and forces of the atom -- and of the great good as well as evil this knowledge can bring -- would be for them to live in a world in which they are, in elementary knowledge, quite blind and unseeing. It would be almost as if they did not know that fire is hot, that water is wet; as if they did not know there are seasons and gravity and magnetism and electricity.*

How should society meet the challenge of nuclear power? Consistent with the modern tendency to seek technical responses to social and political questions, nuclear power promotion has generally focused on strategies to infuse greater technical discipline, order and organization into the social structure. For the technically minded, the greatest threats to progress in the Nuclear Project are human error and political interference and, therefore, attention has concentrated on systems with diminished human-political presence and activism, a greater reliance on machine autonomy (e.g., the inclusion of automatic shutdown and redundancy features), and the search for long-term solutions through scientific research and development. It is in this spirit that the nuclear science and technology community advocate "inherently safe" reactor designs, refined emergency systems, more and better machines to monitor machine behavior and to serve as back-ups in the event of malfunction, upgraded technical credentials and training of system personnel, the substitution of technical reviews for political oversight, regulatory decisionmaking by scientists and technologists instead of lawyers or politicians, and bigger nuclear R & D budgets.

Yet, even these responses are unlikely to resolve the deeper issue which has most worried scientific proponents of nuclear power (Lilienthal, 1949, p. 151):

> *In a democracy public thinking that is dominated by great fear, by phantasy, or by indifference to one of the central facts of our century provides a sorry foundation for the strains we may find it necessary to withstand, the hard decisions we must make, and the opportunities for a peaceful world we must develop.*

Democratic forms and values must reflect the scientific and technological realities of nuclear power. Alvin Weinberg foresaw this dilemma in 1972 when he pointed out that, while the probability of life-threatening nuclear plant accidents is low, expanded use of the technology will lead to an increased frequency of accidents and enlarged risks and hazards. In this respect, the "strains" and "hard decisions" forecast by Lilienthal were inevitable and inescapable. Weinberg realized what needed to be done (1972, pp. 33-34):

> *We nuclear people have made a Faustian bargain with society. On the one hand, we offer -- in the catalytic nuclear burner -- an inexhaustible source of energy . . . . But the price that we demand of society . . . is both a vigilance and a longevity of our social institutions . . . . In a way, all of this was anticipated during the old debates over nuclear weapons . . . . In exchange for atomic peace, we have had to manage and control nuclear weapons . . . . [W]e have established a military priesthood which guards against inadvertent use of nuclear weapons, which maintains . . . a precarious balance between readiness to go to war and vigilance against human errors that would precipitate war . . . . [P]eaceful nuclear energy probably will make demands of the same sort on our society, and possibly of even longer duration.*

Secrecy and security considerations have always figured prominently in the case of nuclear technology, but their presence is typically assumed to derive from social demands for safety on the one hand, and protection against a military reversion of the peaceful atom on the other (ranging from "terrorist" sabotage to irresponsible state conversions of "civilian" programs). Weinberg's insight is to recognize the obverse purpose in garrisoning the Nuclear Project -- to secure this technology from precipitous social abandonment. The fear within the technostructure is that ill-informed public officials, mass hysteria and contemporary Luddite orientations may combine in the aftermath of nuclear accidents to weaken social resolve and perhaps even foster irrational actions to dismantle the Project. By restructuring societies around an institutional complex managed by a technical and military priesthood, a reliable, stable social environment can be created in which 1,000 year nuclear security zones (which is the estimated period of hazard for most radioactive waste) are sited to address the social and political challenges of the atomic adventure (Weinberg, 1979, pp. 94-95; Anderson et al., 1980, p. 30).

The political outlines of the Weinberg proposal are not new. They were themselves foreseen by Henri Saint-Simon in the earliest stages of the Scientific Era (in Taylor, 1975, pp. 83-85):

> *The nation's members vote each year, as individuals, to elect the five best physicists, mathematicians, astronomers, chemists, physiologists, and authors. These thirty scientists are joined by five artists and ten persons chosen from industry.*
>
> *The assembly of these forty-five men of genius will be called Parliament of Improvement . .*
>
> *All enlightened peoples will adopt the view that men of genius should be given the highest social standing.*

If society adheres to its part of the Faustian bargain, nuclear development can complete the promise of worldwide social parity, according to its proponents. Its first-order contribution is a *"fabulous productiveness that has not exacted our essential freedom as its price, but indeed can be made to increase the sum total of freedom of choice for the individual"* (Lilienthal, 1949, p. 126). Provided that the necessary social commitment and support is forthcoming, an even greater contribution to equality is possible. In easily the most original comparison of conservation and nuclear power we have read, Lilienthal offers a glimpse of the technical vision of equality and the obstacles to its realization (1980, pp. 111, 112):

> *Conservation . . . isn't this nothing more than a kind of isolationism in a particularly heartless form, an elitist disguise to mask putting a limit on total energy production, thereby slowing economic growth for those who need growth the most? . . . The only escape from this sinister and destructive meanness is to frame policies that recognize our ethical responsibility toward other peoples on the planet as fellow members of a world community. This task cannot be dismissed as empty idealism; it is the only practical problem for the long run. Unless we make a major contribution toward easing the world energy shortage -- instead of merely satisfying our own needs -- we may be creating for our children's children a life of constant crises and chronic insecurity.*

By this definition of the challenge, we can reject a nuclear future only at the risk of harming worldwide development. Nuclear power is an imperative for modern hopes of abundance, emancipation, and equality.

Nuclear Realities: Elite Power, Centralization and Technical Invasion

Contemporary ideas of technological equality represent a basic distortion of political language and discourse. Self-contradictory notions of democratic elitism and benign authoritarianism are promoted while certain items in the political vocabulary -- in particular, citizenship, participation, access and accountability -- are trivialized. We are left with a stunted language which, not surprisingly, fails to alert us to the reductionism inherent in the treatment of social emancipation and equality as derivative states of materialist abundance.

Beyond the effect on language and discourse, the technicization of politics threatens to corrupt political understanding and analysis. In the specific case of the Nuclear Project, we are at risk of: (1) failing to recognize the elite nature of the technology and the socio-technical system it spawns; (2) failing to describe and explain the centralization of military, corporate, scientific and state power associated with the investigation and development of nuclear energy; and (3) failing to address the real and imminent danger that this technology poses to autonomous social development throughout the world. Below we offer an analysis of each of these concerns.

Nuclear Elitism

Elite rule is a necessary requirement of Nuclear Society. An elite is needed to fulfill three interrelated functions. First, provision and extension of specialized knowledge and expertise is necessary to ensure safe and efficient operation of the system. Because of nuclear energy's intimate relation with nuclear weapons, an elite is also needed to maintain comprehensive security for the enterprise. Finally, a nuclear system depends upon an elite to manage the long-term threat posed by the routine operations of the system itself, including waste generation and the stockpiling of enriched fissionable material. In fulfilling these social functions, the Nuclear Project's rulers have no direct interest in democratic principles or social justice. Popular regard for these values may lead the elite to fashion industrial operations in a manner which recognizes such sentiment, but it is neither their objective nor their intent to democratize the technology or the technical system. Their interest in social engineering lies elsewhere, in the legitimation and maintenance of their elite rule.

Weinberg has pointed to a belief among utility executives that *"a nuclear plant [is] just like another generating plant"* (1979, p. 105). This view is enormously mistaken: *"[T]he responsibility borne by the nuclear operator is so great that he and his staff must be regarded -- and trained -- as an elite."* A professionalized cadre is, according to Weinberg, *"necessary to keep the nuclear enterprise out of trouble"* (1979, p. 105). Western societies are periodically reminded of the specialist nature of the enterprise by the occurrence of (in the special language of nuclear regulation) "technical incidents" and "nuclear events." The requirement of elite rule derives substantially from the nature of nuclear mistakes. The complexity of nuclear accidents is so great that at least some have asserted the impossibility and inappropriateness of probability analysis to assess them (Perrow, 1984). Moreover, the catastrophic consequences of machine failure and human error in the nuclear enterprise lifts this industrial operation out of the ordinary safety vs. profits compromises of business-as-usual. Weinberg argues that recent incidents should serve as *"powerful medicine for clearing one's brain"* of any confusion regarding the special social status of nuclear operations (1979, p. 104). In an argument that is reminiscent of Galbraith's analysis of the modern corporate economy (1967), Weinberg suggests that the nuclear technostructure has far greater social significance than the owner class: *"the pilot and operator bear a heavier burden of direct responsibility for people's lives than do their respective bosses"* (1979, p. 105).

Scientific and technological expertise is only one root of nuclear elite rule. Alongside the cadre of technical specialists is a security apparatus formally charged with preventing "terrorists and saboteurs" from diverting fissionable material to non-peaceful uses. In fact this apparatus is an outgrowth of the military origin of nuclear energy development.

The technical possibility of nuclear power was an inherited one. Knowledge of how to control a nuclear reaction and utilize the heat energy given by it evolved from scientific understanding of the possibility of an atomic chain reaction. Although two options could be identified, namely, setting off a chain reaction or controlling one, from a technical point of view the development sequence and direction were predetermined. Given the state of scientific and technical knowledge and the institutional organization of Western research and engineering on the eve of World War II, the first option involved much simpler technical problems and logically preceded the second. Control methods necessary for bomb-making could be quickly attained, while control methods for nuclear-based electrical and heat generation were more complex and took longer to fashion. In this socio-technical sense, the atomic bomb heralded the nuclear plant (Ellul, 1964, pp. 98-99).

> *Could not atomic engines and atomic power have been discovered without creating the bomb? . . . If atomic research is encouraged, it is obligatory to pass through the stages of the atomic bomb; the bomb represents by far the simplest utilization of atomic energy. The problems involved in the military use of atomic energy are infinitely more simple to resolve than are those involved in its industrial use.*

Even societies which attempted only "peaceful" nuclear development were ultimately incorporated into the military project (Camilleri, 1984, p. 8).

> *Only a few small European nations anxious to capitalize on indigenous technology and independent access to uranium and heavy water -- notably Norway, Sweden, Belgium and the Netherlands -- were able to initiate a modest program of nuclear research and development unrelated to any military objective. But even here the countries in question were dependent, at least in part, on access to fuels and technology which only the existing or aspiring nuclear weapons states could supply.*

One of the architects of the U.S. Nuclear Project, J. Robert Oppenheimer, confirmed that *"the close technical parallelism and interrelation of the peaceful and the military applications of atomic energy"* precluded separate development (1955, pp. 6-9).

> *The science, the technology, the industrial development involved in the so-called beneficial uses of atomic energy appear to be inextricably intertwined with those involved in making atomic weapons . . . The same raw material, uranium, is needed for the use of atomic energy for power as for atomic bombs. . . The same physics which must be learned and studied and extended in one field will help with the other.*

Seen in this context, security considerations are unavoidable. Military interests, regardless of the state, will be asserted in the operation of the nuclear enterprise of bomb and power production. Compromises of civil liberties and rights, including *"security checks, covert surveillance, wiretapping, informers and even emergency measures under martial law"* become legitimate components of system operation (Winner, 1986, p. 37). It is also an expectable consequence of the security framework that hazards such as those recently uncovered in the U.S. nuclear bomb-making complex can go unreported for more than 30 years.

While non-proliferation is certainly part of the goal, its use in explaining elite control should be greeted skeptically. There are numerous instances in which non-proliferation ihas been disregarded in deference to other elite interests. For example, the U.S. recently completed negotiations with Japan to allow the latter to recycle U.S. spent fuel for the purpose of plutonium separation. This agreement waives the long-standing consent requirement exercised by the U.S. in the past in an effort to limit proliferation of plutonium supplies and supply locations (Spector, 1989, pp. 29-30). Elite maintenance, safety considerations and non-proliferation goals are sufficiently intertwined to preclude explanation of security needs on any one of these grounds alone.

The third imperative of elite rule arises out of the unique properties of the nuclear system's principal ingredient. Unlike coal, gas, solar, and other fuel sources, the use of uranium requires the consideration of consequences far beyond the time-frames normally used by society in the evaluation of social and technological systems. As Carter has shown, every stage of the nuclear fuel cycle involves the release or creation of radioactive contamination, some of which will remain lethal to humans for thousands of years (1987). This fact requires both *"a vigilance and longevity of our social institutions,"* which exceeds the governance capacities of traditional political society (Weinberg, 1972, p. 33).

While many in the nuclear community argue that deep-site geological storage will safely protect future generations from the worst of the hazards produced by the 20th century, even the most optimistic recognize the potential dangers of the waste disposal process. As Weinberg points out, some measure of permanent surveillance will be necessary *"if only to prevent men in the future from drilling holes in the burial ground"* (1972, p. 34). In the case of high-level waste even a perfected system of geological disposal will require extraordinary care in the packaging, transportation, and site handling of the wastes. Under present disposal regimes, for instance, a decommissioned reactor and its associated systems (pipes, robotic handling equipment, and so forth) will require a "cooling off" period of between 50 and 100 years. Thus, even if the as-yet-unproven disposal technologies function tolerably, an elite will be required to manage the waste stream over several generations to come. It is in this context that Weinberg proposed the institutionalization of a "nuclear priesthood". Not only must the present generation accept the priesthood as a condition of its survival, so long as wastes are active their security must be guaranteed. In this respect, the present generation of nuclear builders has set conditions for the survival not only of themselves but of many future generations as well.

Again, such a rationale for elite rule should be considered carefully. It is in the self-interest of the Nuclear Project to expand and radioactively enrich the waste stream. Increased waste means increased use of nuclear power; and as the Committee for Economic Development has pointed out, *"any nation that invests in nuclear power reactors . . . will be motivated to economize nuclear fuels and to consider the likelihood that facilities for plutonium separation, even if not now economic, may become so within the period of a nuclear power development plan"* (1977, p. 30). The consequence of expansion and enrichment is an endogenous stockpiling of bomb-grade material and highly toxic "feeder" waste. The resulting plutonium economy presumes a highly militaristic and authoritarian social system (Ayre, 1975, p. 443):

> *With the passage of time and the increase in the quantity of plutonium in existence will come pressure to eliminate the traditional checks the courts and legislatures place on the activities of the executive and to develop more powerful central authority better able to enforce strict safeguards.*

The nuclear elite is part of a "technocratic image" which dominates contemporary ways of thinking and acting (Gunnell, 1982). In a technological society, equality does not refer to the opportunity to participate in a process meant to determine the goals and purposes of social action. Rather, participation is a consumptive act unrelated to acts of a social or communal nature. The function of political leadership is to assess the material wishes of the people and structure the production process in a way which will assure the efficient delivery of the desired goods and services. Politics becomes defined as the management of things best carried out by a qualified elite equipped with tools sufficient for the task. Society is told that the elite serves as a benign instrumentality necessary for the fulfillment of material abundance, social emancipation, and, eventually, social equality.

This portrayal of a technocratic elite resembles past elite justifications for regimes of dynastic and oligarchic rule. In these political systems, social chances were held to be necessarily unequal, since the majority of people were incapable of either creating or following rules of social conduct which required active or sustained participation in a political process. Only the noble and wealthy classes had the vision, foresight and skill required to make these decisions necessary to preserve social stability. Yet, stability was merely an intermediate goal: at the root of elite ideology was the desire to preserve, protect and enhance the privileges and control of a few.

Technological politics represents a step backwards into earlier regimes of political authority which sought to limit rather than expand the condition required for social equality. The one difference between the two elite styles is that earlier representatives were clear in their desire for inequality; the nuclear elite is not as forthcoming.

The Nuclear Consortium

While the quest for energy abundance spans the last two hundred years, twentieth century articulation of the energy-civilization equation is distinctive. The modern search for an "abundant energy machine" resides within an institutional context *"dominated by large-scale programs that offer the promise of technological spectaculars, that involve billions of dollars in expenditures and casts of thousands, and that can only be managed effectively by large techno-bureaucracies"* (Byrne and Rick, 1986, p. 145). It is from this institutional framework that the nuclear promise of limitless power is fashioned.

Throughout this century, the electric industry has sought profitability through integration, pursuing an organizational strategy which Thomas Hughes has termed the "network of power" (1983). This strategy has been based on four components: the holding company, a state regulatory system, an industrial science and engineering system, and the elminiation of local political jurisdiction in policy matters (including the original municipal franchise system). The Nuclear Project promised a technology that was not only compatible with this framework but would actually enhance its principal characteristics. The other primary institutional influence on nuclear power was its outgrowth from national efforts to civilianize the science and technology of the Manahattan Project. These precedents contributed to nuclear's political orientation toward centralization, hierarchy and secrecy.

At the turn of the century, the U.S. electric industry was a highly competitive but fragmented business. In Chicago alone, over 30 utilities were serving the city *"despite the fact that only five thousand persons out of a population of one million used electric lights"* (Anderson, 1981, p. 34). The heavily capital-intensive nature of electricity production and distribution made an industry of small generators paticularly vulnerable to financial and economic downturns. Large scale offered a potentially effective and profitable solution to problems of risk, instability and competition which otherwise would have stymied expansion. General Electric (GE) provided a model for solving ghe problem by creating a holding company specifically for the purpose of leveraging additional capital. Electric Bond and Share (EB&S) assumed the utility bond and stock holdings of GE and utilized them to gather finance capital through the sale of EB&S bonds and stock. As part of the EB&S package, affiliated utilities accepted "service contracts" with the Company for the delivery of engineering and management expertise. In this way EB&S achieved functional control of utility operations without the need (or expense) of acquiring a majority interest through the purchase of voting stock. This financial scheme and the service contract together heralded the arrival of the integrated corporate system, essential for the successful development of an integrated power planning and production system. Samuel Insull of Consolidated Edison used the integration strategy to pefection, assembling by 1930 a half billion dollar utility empire spread over 32 states, serving 4.5 million customers and accounting for nearly 10 percent of total U.S. electric sales (Hyman, 1985, p. 78).

The other major obstacle to the development of a fully integrated, centralized power system was political. The U.S. municipal franchise system, originally instituted at the encouragement of producers and distributors for the purpose of rationalizing competitive markets, resulted in small service territories with correspondingly small utility profits. Led by Insull, the National Electric Light Association (the industry's trade association), lobbied for monopoly status and state regulation. This movement had the dual function of freeing the utilities from local control and, at the same, time mounting an effective resistance to the growing threat of municipal utility ownership (Anderson, 1981).

The combined impact of these organizational, financial and political innovations was to substantially expand the scale, size and quantity of power production in the U.S., as well as the amount of revenues and profits. The new regulatory environment and the integrated utility structure touched off a sustained period of mergers in the industry as small local generators were brought into the networks of holding companies. Even many municipally owned plants were eventually taken over in this manner. In 1926 alone, over 1,000 mergers were undertaken, and by 1955 approximately 500 private companies controlled 80 percent of national sales. Since then, the number of companies has been halved while the percentage of total sales controlled by these companies has remained nearly the same (Messing, et. al., 1979, pp. 45-46; Hughes, 1983, pp. 201-226 and 391-394). An equally significant consequence of the revised social environment was the growth in the size of power plants. Generating capacities which averaged 7.5 kw in the 1880s increased to 200,000 kw in 1930 and by 1955 it was possible to construct 1,000 MW plants (Messing, et. al., 1979, p. 3). Thus, well before the introduction of nuclear technology, a common effort of organization, capital, technology and production method was in existence to produce large supplies of electricity. This vertically and horizontally integrated system replaced the haphazard, competitive basis of accumulation, with one rooted in principles of control.

With the demonstration in late 1938 of nuclear fission, the new world entered a new and threatening era. By time of the attack on Pearl Harbor, nearly 150 senior scientists with a budget of over $2.7 million, were involved in the U.S. in research projects investigating the feasibility of atomic weapons. When Enrico Fermi successfully produced a nuclear chain reaction in December 1942 (using a squash court under the west stands of Stagg Field, the University of Chicago's unused football stadium, development of the most destructive weapon imaginable was assured (Kevles, 1977, p. 326).

Franklin Roosevelt's approval of an "all out effort" on December 28, 1942, brought together the nation's largest corporations to assist in the production of the nuclear bomb. The list included DuPont, General Electric, Westinghouse, Union Carbide and Carbon, Stone and Webster, Chrysler, Allis Chalmers, Republic Steel, International Nickel, and Eastman Kodak. To accomplish the task, a giant industrial complex was erected consisting of thirty-seven installations in nineteen states and Canada, 254 military officers, approximately 4,000 scientific adn technical personnel, and a $2.2 billion wartime expenditure (Hewlett and Anderson, 1962, p. 2). The entire apparatus had been built without public consent, and most of it without public knowledge.

The scientific and technological infrastructure created for the Manhattan Project underwent "civilianization" after the end of World War II. A substantial piece of the infrastructure was directed under the 1946 Atomic Energy Act to promote the "peaceful use of the atom." The enabling legislation created the Atomic Energy Commission (AEC) with wide security and secrecy powers. This expert government was granted sole ownership and control over the production of fissionable materials; was authorized to organize a national laboratory system to pursue basic and applied nuclear research; and was vested with responsibility for commercializing nuclear-generated electric power. This national monopoly expanded upon the already existing state and regional centralization of authority which characterized the utility industry.

The prognosis for commerical nuclear power at the time was anything but optimistic. A scientific advisory board organized to assist the AEC in identifying research and development needs concluded it did *"not see how it would be possible under the most favorable curcumstances to have any considerable portion of the present power supply of the world replaced by nuclear fuel before the expiration of twenty years"* (see the General Advisory Committee's 1947 Draft Note on Atomic Power cited in Hewlett and Duncan, 1969, pp. 116-117). A prominent economist in 1949 concluded that nuclear power was uneconomical in the short- and probably the long-run (Isard and Whitney, 1949). And a national study completed in 1965 found no looming fuel shortage which would rationalize the extensive use of expensive nuclear power (Energy R and D and National Progress, 1965). Nonetheless, the AEC proceeded with nuclear reactor development and commercialization, underwriting the R&D, supplying the fuel at no charge, gaining a liability ceiling for utility operators in the event of a plant accident, and coordinating with reactor suppliers to relieve utilities of capital obligations for the initial plants. In this respect, *"nuclear power was not the invention of enterprise; there was no market demand for it ... prior to its institutionalization;"* *rather, "the U.S. set about to discover and affirm the advantages of nuclear power and to discount its costs without any knowledge of its economic practicality and before the technical means exsted to deliver it"* (Byrne and Rich, 1986, p. 153).

AEC's method for achieving its goal of reactor commercialization was nearly identical to that employed in the Manhattan Project: Combine Big Science, Big Industry and Big Government to achieve big results. The AEC was the home of Big Science, its laboratories serving as the "factories" for technology development (Seidel, 1986). The agency relied on a close circle of corporate and university giants to carry out the mission: through the 1960s, the AEC distributed over half of its expenditures to just five companies -- Dupont, General Electric, Union Carbide, Bendix and Sandia, and two schools -- the University of Chicago and the University of California. This preference for bigness was explained by the need *"to get work done and yet maintain that tight control needed in top secret organizations"* (Orlans, 1967, p. 21).

Political secrecy and distance were highly valued means for maintaining the centralist pattern of technology development. An aura was created around the apparatus which reserved knowledge, access and even criticism to the few who could claim scientific and technical literacy. Thus, the leader of the newly organized Federation of Atomic Scientists cautioned members that "we must be sure that other groups which have no scientific interests at heart and no background do not join us openly" (quoted in Hewlett and Anderson, 1962, p. 447). As Lilienthal observed, only a limited group of scientists knew and understood the "official mystery and complexity of atomic energy. They were the experts; they knew it all; it was over the heads of the public, and public critics were held in disdain" (1980, p. 30).

Out of the view (and criticism) of the public, and guided by an organizational maxim of "bigger and fewer partners is better," the AEC-led alliance of industry, the state and science achieved a suitably centralized technological result. Nuclear power intensified progress in central station technology, increasing by several orders of magnitude the steam pressures, boiler and turbine capacities and thermal efficiencies of units. Even more significant was its impact on

megawattage. The introduction of nuclear power raised average plant size from 400-500 MW to over 800 MW and set a new ceiling of 1,300 MW. As a result, commerical interest in and research on small- and medium-scale facilities virtually ceased (Messing, et al., 1979, p. 7-8). Nuclear power not only accommodated earlier centralist tendencies, it augmented them (Byrne and Hoffman, 1988, p. 622):

> *This technology inaugurated a new planning reality for the utility industry ... Grid interconnections, wheeling techniques and new transmission line technology assumed prominent roles in industry thinking and have become adjuncts of the new reality stimulated by nuclear power. In this respect, whatever the extent of its eventual use, nuclear power has already so affected the technical environment as to constitute a new root for reticulating electrical technique.*

The electrical network as it developed in the 20th century was a force for technocratic rule, not democratic governance. The Nuclear Project reinforced this orientation, adding political secrecy and security to the institutional apparatus. It sought and obtained institutional autonomy andaccumulated power at the expense of democratic social institutions. In this respect, nuclear power served to extend and amplify institutional inequalities immanent in technological society. Atomic power plants and bombs are evidence of the power of a consortium of centralist institutions to shape modern social history.

The Universalization of Nuclear Technique

The penetration of nuclear technology into all parts of the world has been both rapid and sustained despite very high capital requirements and numerous outstanding safety concerns. Between 1984 and 1985, for example, nuclear capacity increased 14 percent following a 19 percent increase from 1983 to 1984 (U.S. Department of Energy, 1987, p. 183). Growth continued in 1987 after Chernobyl, as 21,076 MW of new nuclear capacity were connected to electrical grids for the first time (Nuclear News, March, 1988, p. 86). According to the U.S. Department of Energy (DOE), the 416 reactors currently on-line will grown to 500 by the end of 1990 if current construction schedules are met (DOE, 1987, p. 183). Construction orders from 118 plants remain for start-up by 1990, including new orders by Japan, the Soviet Union and Great Britain (Ramberg, 1986, p. 318). For many in the nuclear community, the question of expansionism is settled. Llewellyn King, editor of Energy Daily, recently declared that the *"nuclear industry's place is secure; its present is difficult. By the mid-1990's alternative energy systems, such as solar, which have been found wanting, will not be suitable or adequate and we are going to go nuclear. The whole world is going to go nuclear"* (Nuclear News, January 1987, p. 90). Remy Carle, director general of Elecricite de France's Engineering and Construction Division, echoed the point in a post-Chernobyl assessment of nuclear power, warning that abandonment of the technology *"would involve such great tensions on the energy market that [it] would endanger world peace, with all the resulting catastrophic consequences"* (Nuclear News, January, 1987, p. 84).

Nuclear expansion has been particularly robust in the Third World. China is currently completing the construction of two 900 MW pressurized water reactors (PWR) and is itself building a 300 MW PWR at Quinshan: the latter will be supplemented by two additional 600 MW PWRs in the near future (Nuclear News, November 1987, pp. 98-99). India has contracted to purchase two 1000 mw reactors from the Soviet Union in the largest single foreign purchase it has ever made. The reactors are part of India's plan to add 10,000 MW of nuclear energy to its electrical network by the year 2000 (India Today, May 15, 1988, p. 87). South Korea has highly expansive nuclear ambitions, recently agreeing to add two 1000 MW reactors to that country; these units will supplement the 10 units either operating or in the Korean pipeline (Power Engineering, April, 1988, p. 10; Payne, 1987, p. 59). And a recent university study concluded that the country would require 55 new nuclear plants to meet electricity needs through the year 2031 (Chosen Daily News, June 2, 1989, p. 31). Less grandoise, Taiwan has 6 units in place with a rated capacity of 4918 MW. Active nuclear programs are also found in Pakistan, South Africa and in many countries of Eastern Europe (Borg, 1987). Developing countries of the Western hemisphere are also pursuing nuclear technology. Undeterred by the 1987 radiological accident at Goiania (Petterson, 1988), Brazil recently announced the privatization of its National Nuclear Energy Committee (CNEN) as a way of bolstering that country's long-standing commitment to the technology (Nuclear News, October, 1988, p. 59). Also in 1988, Brazil opened an advanced uranium enrichment plant (The Economist, 1988, p. 86) and signed a pact of cooperation with Argentina for purposes of exploring the joint development of a breeder reactor and other nuclear options (Perera, 1987, p. 39). Currently, Brazil and Argentina both operate nuclear facilities capable of producing bomb-grade plutonium (Spector, 1989, p. 31). Cuba is proceeding with the construction of a 4-unit complex (U.S. Senate, 1986) and Mexico recently announced it's intention to begin operating the first of two 654 MW reactors located at Laguna Verde on the shores of the Gulf of Mexico.

The attraction of nuclear technology to the South is rooted in the themes of technological equality promulgated in the West. India's energy planners for instance, regard nuclear power as an *"ultimate dream."* (India Today, 1988, p. 87) to be valued not merely for its capacity to generate electricity, but as an essential technology for rescuing the developing world *"from the shackles of poverty and ignorance"* (Indira Ghandi quoted in Pathak, 1980, pp. 24-25). Through nuclear power, the South searches for the energy required to industrialize and thereby secure the material advantages currently possessed only by the West. Alder captures the full extent of the relationships among technology, development and equality in his description of the motive forces driving Brazil's and Argentina's quest for "nuclear autonomy" (Adler, 1988, p. 18):

> *Progress from the perspective [of the developing countries] means only going forward, and anyone in the rich countries who suggests that such movement should be slowed down or redefined is accused of wanting to prevent the developing countries from achieving a measure of equality. Thus progress is viewed by the developing countries not only as modernization and economic and technological development but as a matter of autonomy and equality as well. This is why their nationalist ideology is so strongly linked to development and equality. Liberation, cultural self-affirmation, development, science and technology: these are the core dimensions of the idea of progress in the Third World.*

As Poneman points out, ownership of a plant is being assumed by many in the South as a indication that they are on the road to achieving developmental parity with the West (1982, pp. 123-125):

> *(T)he ability to harness the atom for scientific and ultimately commercial purposes . . . measures advancement and independence relative to the industrialized countries . . . . Large projects [such as nuclear plants] often appeal to developing country governments as a means to demonstrate their ability. Because of its complexity, perhaps even its mystery, the mastery of nuclear technology can instill popular pride.*

Although the aspirations that drive developing countries to accept this technique are the achievement of development autonomy and parity, in fact, they are in danger of becoming recolonized, this time by technological means. Far from breaking the cycle of dependency, the exploitation of nuclear power has only deepened reliance of the developing world on the capital and expertise of industrialized countries. French experts, with experience gained from efforts in South Africa and Pakistan, are supervising the Chinese nuclear projects; West German firms are serving as principal engineers and suppliers to both Brazil and Argentina; the Soviet Union is providing similar support to India, Cuba, and the Eastern Bloc; and major U.S. firms such as Westinghouse, Bechtel, Combustion Engineering and general Eelctric market nuclear machines and expertise throughout the globe.

The capital requirements of nuclear plants also serve as a development trap for Third World buyers. The Philippines' purchase of a Westinghouse reactor illustrates the problem. The acquisition of the $2.1 billion plant was financed by a $550 million loan from the U.S. Export-Import Bank (an agency of the U.S. government responsible for the promotion of overseas sales of U.S. products), and additional loans by Citicorp and Swiss and Japanese banks. Interest on the loans is approximately $300,000 per day, and annual finance costs are projected to be $249 million through 1993. The plant has never been operated and there is no expectation that it will be due to its location on a geologic fault (Los Angeles Times, June 12, 1986, p. 12-13).

The attachment of value to technique has been described by Jacques Ellul as part of a general process of technical invasion in which cultural resistance is rarely effective. Technical considerations overwhelm and displace alternative principles of social evaluation: *"[T]echnique can leave nothing untouched in a civilization everything is its concern . . . . It is a whole civilization unto itself"* (Ellul, 1964, pp. 125-126). This logic of technical advance points out the precarious status of traditional social and political boundaries: *"[U]ntil now, it was generally accepted that very similar social environments were necessary if propagation of techniques were to occur. This is no longer true. Today technique imposes itself whatever the environment"* (Ellul, 1964, p. 118).

Rather than mimicking Western technological institutions, developmental parity depends upon each society having the power to determine how best to meet its present and future needs given the historical cultural context in which it finds itself. The universalization of nuclear technique at the very least impedes parity, and most likely prevents it.

Conclusion

Sobered by events in the 17 years since he termed nuclear power a "magical energy source" and 33 years since he encouraged its development as contributing to a "gentler" way of life, Weinberg is still hopeful that we may achieve a Nuclear Society, concluding that the *"technical means to ending our dependence on fossil fuels"* lies in *"inherently safe fission reactors that are both economical and acceptable to the . . . public"* (1989, p. 85). Nuclear power has been consistently identified by its advocates as the limitless energy source able to fulfill Western culture's search for affluence and equality. The costs of societal investment in this promise have been numerous. But perhaps the most significant and alarming is in the sublimation of political being and aspirations. Lewis Mumford warned us 25 years ago of *"the bargain . . . that takes the form of a magnificent bribe"* (Mumford, 1964, p. 6):

> *Under the democratic-authoritarian social contract, each member of the community may claim every material advantage, every intellectual and emotional stimulus he may desire, in quantities hardly available hitherto even for a restricted minority: food, housing, swift transportation, instantaneous communication, medical care, entertainment, education. But on one condition: that one must not . . . ask for [something]the system does not provide, but likewise agree to take everything offered, duly processed and fabricated, harmonized and equalized, in the precise quantities that the system, rather than the person, requires.*

The Nuclear Project demands that we accept a politics without substance in exchange for a promise of abundance. The challenge to contemporary society is to realize the hollowness of the bargain and to revitalize its political language and understanding.

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An Overview of

MISSION 21

A Program Designed to Assist Teachers in Integrating Technology into their Present Curriculum Through a Problem-Solving Approach

Information presented in this paper was compiled by:

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Introduction

This paper presents a brief overview of Mission 21, a Virginia Polytechnic Institute and State University project funded by the National Aeronautics and Space Administration (NASA) to promote technological literacy in the elementary school classroom. Funded since 1985, Mission 21 has enabled graduate research associates to work with elementary school teachers in the Commonwealth of Virginia to write and field test an innovative program for children in grades 1-6. Currently, there are over thirty elementary classroom teachers in ten school systems throughout Virginia involved in field testing Mission 21 materials.

The Mission 21 resource guide provides direction to elementary school teachers. Teachers use this information to facilitate the integration of concepts related to technology with their present curriculum. Activities throughout the guide are exciting, emphasizing creativity for all children using a problem-solving approach to learning. The productive realization of these concepts enhances students' knowledge and promotes technological literacy.

For clarification purposes, the following definitions are provided.

Technology	The study of the application of knowledge, creativity, and resources to solve problems and extend human potential.
Technology Education	The school discipline for the study of the application of knowledge, creativity, and resources to solve problems and extend human potential.
Technological Literacy	Comprehension of ways that technology affects and is affected by individuals, institutions, objects, and processes and the ability to function in an informed, effective manner on the basis of this understanding.

Mission 21: A Rationale

Technology is prevalent in society. People depend on technological developments to simplify their lives and contribute to solving problems. Technology makes it possible to transport people and products around the world and instantly communicate across international borders and into space. It enables products to be made that make jobs less tedious and leisure time more enjoyable. It also provides an abundant energy supply for a mobile, productive, safe, and comfortable society.

But, technology can also create problems. Technological wizardry has raised cause for concern in areas like biotechnology and nuclear energy. Because technology has enhanced human capabilities to create, produce, reproduce, and destroy, some people sense that technology is in control.

Unless people fully understand the technological world in which they live, they cannot effectively fulfill their roles as citizens, workers, and consumers. The human-made environment is made possible through technological innovation and human ingenuity. But, do people recognize the limits of natural resources upon which technology is dependent? Are they cognizant of new innovations that may alter lifestyles? Do people appreciate the strides made in technology that have improved the American standard of living and opened a new frontier in space?

Through technology education in the elementary school, children can become aware of their technological world and explore the assets and liabilities of this prevalent force in our society. Teaching strategies and learning activities that promote an understanding of technology and the analysis of technological issues and trends can prepare children to deal with the problems and solutions of the 21st century.

NASA Promotes Technological Literacy

The National Aeronautics & Space Administration (NASA) has recognized the need to take an aggressive role in the promotion of technological literacy in America's schools. Through Operation Liftoff, NASA made a commitment to becoming more involved in the development and dissemination of educational materials that focus on the elementary school community. This initiative was designed to stimulate students' interest in the study of technology, mathematics, and science in an effort to ensure their active participation in an increasingly technological society.

As part of this effort, NASA awarded a training grant to the Technology Education Program Area of the College of Education at Virginia Polytechnic Institute and State University (Virginia Tech) in June, 1985. The grant enabled Virginia Tech to hire graduate students as research associates. These individuals developed the rationale and structure of an innovative program to promote technological literacy in the elementary school through a problem-solving approach. The program, titled Mission 21, signifies the focus of the program towards preparing citizens, workers, and consumers for the 21st century.

In cooperation with elementary school teachers throughout Virginia, technology education resource materials and activity ideas have been developed and are in the process of being field tested at the third through sixth grade levels. It is expected that the program will be expanded to include the first and second grade level by 1990.

Mission 21: A Resource for Teachers

The Mission 21 resource guides are intended to help elementary school teachers implement technology education concepts into their existing curriculum through a variety of activities emphasizing creativity and problem-solving. The purposes of the teacher resource guides are to:

- Establish a feasible framework in which to implement the study of technology into the elementary school curriculum.
- Provide teachers with unique learning activity ideas that can serve as a springboard to new classroom projects, explorations, and experiences.
- Emphasize the importance of creativity and problem-solving as factors to improving student comprehension and analysis of technological problems and solutions.
- Suggest problem-solving themes that can be used to teach children about technology and space.
- Provide teachers with basic information for planning and teaching about technology and space.
- Encourage teachers to use available resources to enhance the curriculum and promote technological literacy.
- Facilitate the process of integrating technology education into the elementary school through a flexible program designed to enhance the existing curriculum and broaden the students' understanding of the technological world.

Each resource guide contains four problem-solving themes with sample problem-solving activities, called design briefs. To aid in implementation, teacher hints, resource listings for printed and audio-visual materials, and teaching aids (sample handouts, overhead transparency masters, etc.) are also included in the guide.

The program is designed to be flexible and does not require "special" equipment or materials. All activities can be completed within a typical elementary school classroom using inexpensive or available materials.

The problem-solving themes were chosen to easily fit into the present elementary school curriculum. Teachers are encouraged to find ways to use these materials as a part of existing subjects in the elementary program. See Table 1 for a listing of the problem-solving themes for each grade level.

Table 1. Problem-Solving Themes

Grades 3-4	Grades 5-6
Community	Communication
Connections	Space Colonization
Machines	Inventions
Discovery	Energy and Matter

The program is designed to encourage problem-solving and creative thinking. Although any problem-solving model can be employed, the Mission 21 program includes a unique model for each level. Each problem-solving model is presented on the following page (Figures 1 and 2).

Figure 1. Problem-Solving Model for Grades 3-4

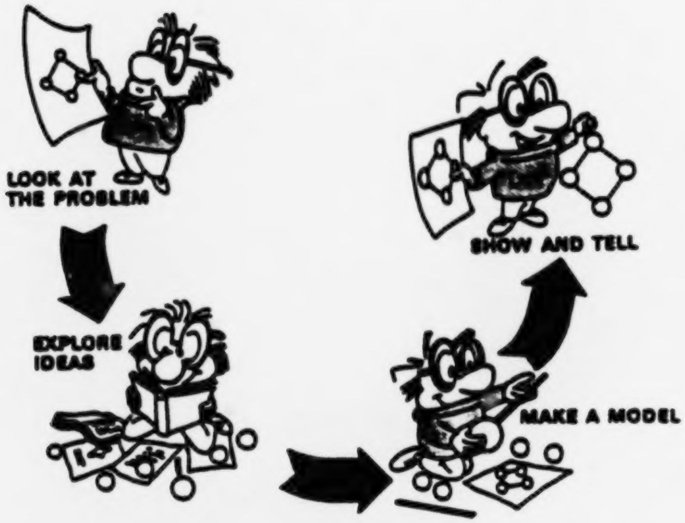
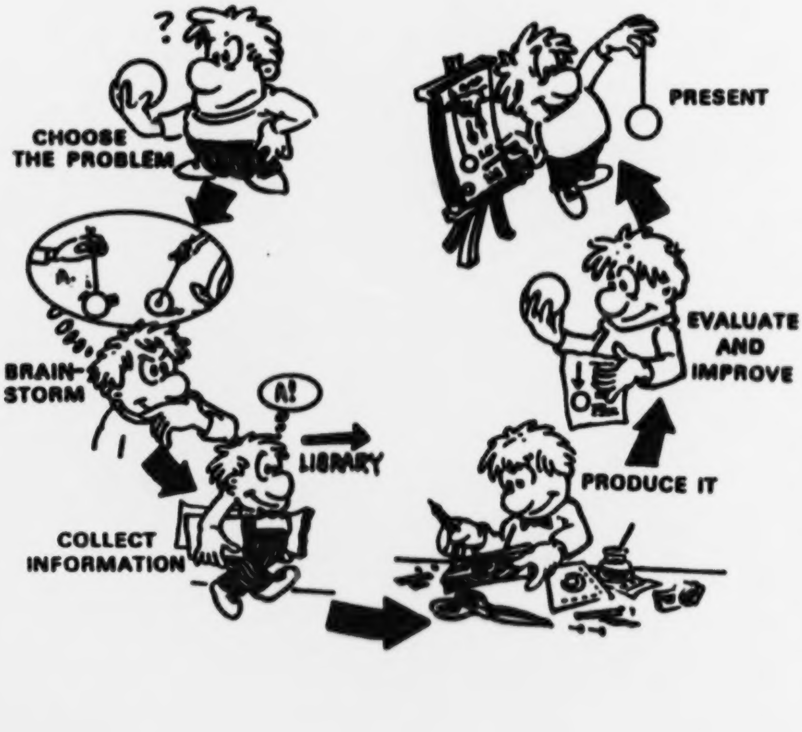

LOOK AT THE PROBLEM
EXPLORE IDEAS
MAKE A MODEL
SHOW AND TELL

Figure 2. Problem-Solving Model for Grades 5-6

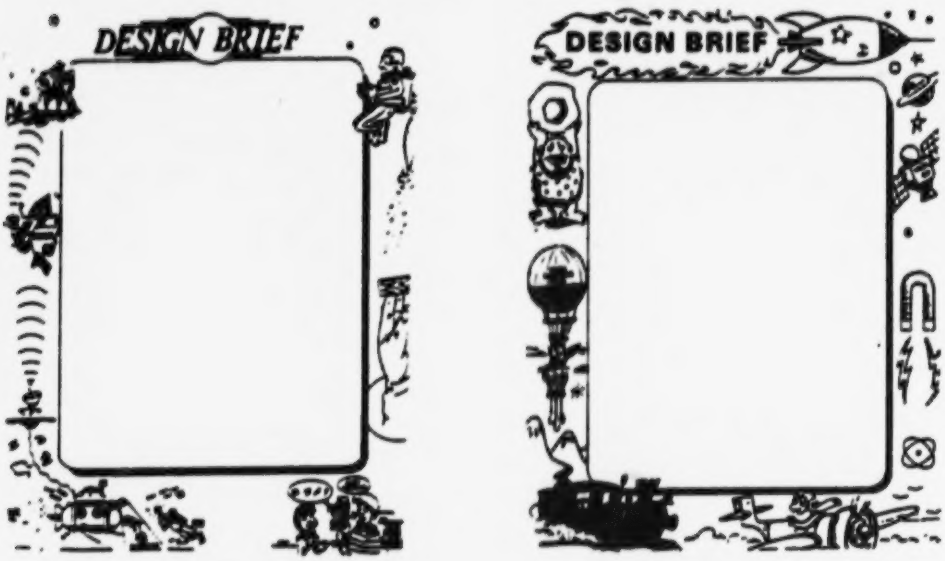

CHOOSE THE PROBLEM
BRAIN-STORM
A!
LIBRARY
COLLECT INFORMATION
PRODUCE IT
EVALUATE AND IMPROVE
PRESENT

Design Briefs: Problem-Solving Activities in Mission 21

A **design brief** is the term given to the formal description of activities in Mission 21 that require the student to examine a given situation and act upon the problem or solution. A design brief describes a situation, which is usually hypothetical, and requests a solution to a given problem. The purpose of the design brief is to encourage the student to think creatively while using the problem-solving process to explore alternative solutions and make decisions regarding an optimum solution to the problem.

In Mission 21, all design briefs are clearly identified by one of the formats shown in Figure 3 below. Teachers can copy the design brief for use in the classroom and use it exactly as it is written. However, they are encouraged to change it to suit their writing style and teaching approach.

Figure 3. Mission 21 Design Brief Formats


Grades 3-4

Grades 5-6

Documenting Students' Progress in Mission 21

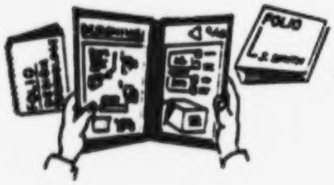
In an effort to document students' progress and application of the problem-solving process, Mission 21 teachers are encouraged to require students to use **folios**. The folio is any of a number of methods that can be employed to encourage students to record information and document their research and problem-solving strategy. The purposes of a folio are to:

- Show a lineage of the students' progress from the beginning of the problem to the final solution OR the beginning of the program to the end of the program.
- Document the students' effort and thought processes which will help the teacher and parents understand what the students have learned and how well the students comprehend the concepts.
- Record students' ideas which can assist them in planning better solutions, recalling information and specifications, and developing the optimum solution to the problem.

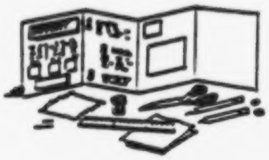
For example, the sketches below (Figure 4) illustrate several folio designs. Though they vary greatly in complexity and format, folios serve one primary function – *to record students' progress through words and pictures.* Teachers are encouraged to provide students with a variety of materials to assist them in preparing folios.

Figure 4. Sample Folio Formats

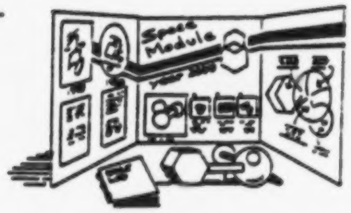
The Journal or Log



The Chronology



The Display



Mission 21: Interdisciplinary Technology Education

The importance of technological studies in the elementary school cannot be overemphasized. Technology affects all aspects of human lives and will continue to be a dominant force in the future. It is imperative that efforts be made to include technological studies throughout children's educational experiences.

Through Mission 21, technology education in the elementary school is not only possible, but can be successful. Mission 21 enhances the elementary school curriculum through flexible problem-solving activities that are easily integrated with science, social studies, math, language arts, health, physical education, and fine arts. Mission 21 is truly an interdisciplinary approach to technology education. Furthermore, Mission 21 motivates students to solve problems, think creatively, and make decisions about technology and the future.

For More Information About Mission 21

Mission 21 is still in the developmental stages and strategies are being explored to publish and disseminate completed materials. In the meantime, all developmental work for Mission 21 is taking place at Virginia Polytechnic Institute and State University. Questions about Mission 21 should be directed to:

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Mission 21 Research Associates
Virginia Polytechnic Institute & State University
Technology Education Program Area
334 Lane Hall
Blacksburg, VA 24061-0254
Phone: (703) 231-4250

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THREE APPROACHES TO TEACHING STS IN THE ELEMENTARY SCHOOL: USING SCIIS, SAPA AND DEVELOPING UNITS AROUND THEMES

Constance H. Gordon

Needed: A New Approach to Teaching STS in Elementary Schools

Many members of the science community agree that elementary science education needs improvement (Hurd, 1984, AAAS, 1982) and suggest ways in which it might be done (Mechling and Oliver, 1983). Because of its concern with the poor geographical knowledge of American students and adults, the National Geographic Society established an education foundation to train geography teachers and improve geography education.

People in the non-scientific community are generally concerned about education and teaching. Students don't know how to think, solve problems and make decisions (National Commission on Excellence in Education, 1983). Students are not excited about education because they don't find it relevant to their daily lives (Sizer, 1984). One solution to the myriad of problems facing teachers and students is to integrate curricula to make apparent the relevance of one subject to the next and of each subject to a student's life (National Science Teachers Association, 1985).

Many influential people feel that one way to upgrade both and to better prepare students to be responsive, informed voters is to teach them the relationships among science, technology and social issues (Roy, 1983). In the pages that follow, the term "integration" is used in discussing the development of these relationships.

When so many agree that integration is necessary, why isn't it happening in all elementary schools in the land? There are many reasons, but in this paper, only motivational focus and resultant approaches to curricular "integration" are considered. Following a discussion of several approaches that have limitations, I present three that have been successful.

Motivational Focus: Barrier to Effective Integration

Designers' motivation for integrating curriculum shapes the way in which it is developed. For example, many school system curriculum developers are motivated by the desire to cover more in a given day. They hear teachers complaining about being unable to cover all that they should. These experts believe that if they could just squeeze subjects together, teachers could cover more. Thus, for these experts, integration means taking existing curriculum and forcing content integration. Most frequently they integrate science and mathematics and, in a separate effort, language arts and social studies. This is an interesting approach, but hardly one that will lead students to see the relevance of science and technology to their social world or *vice versa*. Once the experts have integrated curricula, teachers are still left to determine how to cover the skills for which they are held accountable on standardized and criterion-referenced tests. The primary focus is on teachers and coverage of curriculum, not on children and integration of concepts and skills.

Science/Technology/Society (STS) advocates are motivated by a desire to have good science teaching and content integration that shows the relationships between the development of technology, advances in science and resultant social change. Some, like school system curriculum experts, develop units or modules that are rich in solid content integration for teachers, but develop them in the absence of students. These modules frequently become add-ons to existing curriculum instead of replacing existing content. They also fail to pay sufficient attention to skills. Many STS advocates are middle, junior and senior high school teachers who develop their curriculum based on student interests and grade-level subject requirements. There is still a failure to emphasize skills or to make explicit a process for applying skills across subject areas, as is so essential in early elementary school years.

The focus needs to be on weaving material together in a way that all students will gain both the skills and knowledge they will need. Thus, I define integration as a process of teaching teachers to develop curriculum that teaches students to apply process skills to integrated science and social studies content. What follows is a description of the curricula to be used and three methods of approaching integration I have developed.

The Social Studies Curriculum Today

Though social studies curriculum varies in different localities, there are some features that are consistent throughout the United States (Banks, 1985). The curriculum starts with "knowing oneself" at the Kindergarten level. As the students progress, their horizons expand to studying their family, community, other communities, their state and city or county, the United States and ancient civilizations. Within each year they learn concepts from geography, economics, history, sociology and government.

Two Current Science Curricula

1. Science, A Process Approach (SAPA)

Science, A Process Approach is a K-6 program that involves 15 modules per year (American Association for the Advancement of Science, 1975). Some modules can be completed in a week. Others take a longer time because they require collection of longitudinal data. Each module is developed around one of the 13 science process skills and may be taught in various orders. Modules based on one process skill build on each other so that, in the beginning, the skill is presented in its least complex configuration, then as modules progress, the skill is refined. For example, classification starts with sorting into piles and then evolves into sorting into two categories with several branches and finally evolves into developing a multi-faceted punch-card system for sorting by various attributes.

Each skill area includes modules in physical science and others in natural science. However, though skills come sequentially, one skill lesson may deal with the human body, the next with chemistry and the one after that with physics.

2. Science Curriculum Improvement Study (SCIIS)

Science Curriculum Improvement Study is divided into scientific concepts of matter, energy, organisms and ecosystems, with interaction as the organizing principle of each, and five process-oriented concepts: property, variable, system, reference object and scientific theory (Thier, 1977).

There are two strands, one physical and one life science, at each grade after Kindergarten. Kindergarten is devoted to a year-long sequence that involves learning pre-reading concepts of color, shape, texture, odor, sound, size, quantity, position and organisms. In the life sciences strand, students start with simple organisms and expand to learning about growth cycles, interaction with the environment and ecosystems. In physical sciences, students start by studying simple interactions and expand to examining systems and subsystems, manipulation of systems and development of theories to explain interactions.

An Approach to Integration

For those who wonder why school systems would want to keep their old science curricula, the answer is that both SAPA and SCIIS are excellent, hands-on, scientifically sound, expensive, teacher-proof curricula. School systems don't abandon these programs easily and, when they do, it tends to be for textbooks based on specific subject curricula. Therefore, if school systems are to help teachers do integration, a way needs to be found to help teachers provide the integration using existing materials. This paper provides a process that teachers can use to integrate their current curricula. It also presents a way to create a curriculum, if textbooks or other packaged curricula are not required.

The way to create integration is to teach the skills, which span all curricular areas, and then to integrate the content in any numbers of ways, while teaching students to apply the skills they have learned. When I say "teach the skills," I am suggesting that we need to go farther than we have in the past. It is not sufficient simply to use the skills in science experiments as one does in SCIIS, nor is it sufficient to take students through the process of using skills in a progressively more complicated sequence, as SAPA does so well. Students need to be taught the steps in each process and then allowed to practice applying those steps repeatedly across all content areas.

Figure 1 shows the 13 process skills of science and the match between skills in science, social studies and language. If one were to include reading and math, there would be a complete match. However, my teaching focus is on social studies and science with language as the vehicle of communication, so the skills are presented using only these three subjects.

Once each skill is recognized, it needs to be explicitly taught at an appropriate time in a student's developmental framework. That means, for example, the student needs to be taught the steps to follow in interpreting data, classifying or inferring. Then the student needs to be taught to apply those steps systematically in all subject areas, thus building procedural knowledge, one of the three types of knowledge that are the basis of metacognition (Marzano et al., 1988). Metacognition is being aware of the thought processes one goes through in solving a problem and knowing when and how to use each process. There is a growing body of evidence that indicates that students who are taught when and how to use thinking skills, perform substantially better on standardized tests than do students who are left to solve problems without the explicit training (Joyce & Showers, 1988).

It is important for a teacher to track skills as they are taught and applied in various subject areas. Figure 2 is a record-keeping sheet I developed. The teacher uses a new sheet for each area of science covered. If one were using a skill-based science such as SAPA, one would want to add columns on the right of the worksheet to indicate the content areas of science included over a given period of time.

Once skill areas are accounted for in planned instruction, content can be integrated. Figure 3 shows the content areas traditionally included in elementary science, social studies and language arts. It is important to integrate concepts and/or content, but not to try to integrate at the level of instructional objectives. Objectives are concerned with skills and content too minute for effective integration.

There are several approaches to integration that are appropriate to different content and curricular materials. I present three below: one approach I have used with SAPA, one with SCIIS and one approach for a theme-oriented curriculum

For my examples, I use fourth grade curricula. At fourth grade, social studies students learn about natural environments, including climate, topography, continents and oceans, and natural resources on a general level and then, specifically for the local state and district. They learn skills for reading maps and globes, graphs and time lines, and interpreting data from reference materials, look for cause and effect in history and develop group skills (Prince George's County Public Schools, 1987) (Silver Burdett, 1985).

Fourth grade SAPA uses the skills of predicting, inferring, communicating, using numbers, using space and time, measuring and classifying. Its content includes physical and life sciences and mathematics.

Fourth grade SCIIS physical science content includes the concepts of relative position and motion and the skills of using space and time, controlling variables, interpreting data and inferring. Fourth grade life science content includes study of environments for plants and animals and adds the skills of hypothesizing and experimenting to those included in the physical sciences.

Because SAPA is process-skill based, teachers should use the following steps in integration:

1. Teach the process skill and how to apply it.
2. Teach the science content.
3. Do experiments with science content while practicing application of the skill.
4. Make a connection from the science to the social studies content.
5. Apply the process skill to the social studies content.

As an example, in SAPA module 72, "Heart Rate," students apply the concept of controlling variables. When I taught this module, first, I taught the concept. I presented students with a set of steps for controlling variables as listed in Figure 4. I reminded students of experiments they had performed in the past, in which they had controlled variables, and showed them how they had followed the steps of the process. Then I had them do Module 72 and, at each step, showed them how they were applying the process. They developed an experiment of their own to use the process Then they applied the process to other experiments concerned with body reactions. Next, they made the connection from the science of pulse and circulation to Charles Drew, the developer of the process for preserving blood so that it could be stored and used for transfusions at later times or in different places. Charles Drew is a local historical figure for my students. They discussed the variables Charles Drew must have considered in developing his blood preservation process and the hypotheses he must have made, thus applying the process skill to social studies and linking the scientific content to social studies content.

In integrating the SCIIS curriculum on relative position and motion, a teacher should first examine the skills of each subject area to see which are emphasized and then examine the concepts of science and social studies to see where they mesh. Next he or she should create a flow chart that weaves the two together. That works in the following way.

The skills to be taught in social studies are the skills of using space and time and interpreting data, including seeking cause and effect. The SCIIS skills add to that emphasis on controlling variables and inferring. The content of social studies includes climate, landforms, natural resources, community and state maps, history and government. The SCIIS content starts by reviewing the skill of controlling variables, then presents the concept of relative position using class, school and community maps that emphasize local landmarks. Mapping using both rectangular and polar coordinates is discovered. Relative motion is explored using vehicles, still and moving pictures, and shadows cast by the sun on two dimensional planes and globes. Figure 5 shows one possible flowchart for integrating most of this portion of social studies with this unit in SCIIS. For the spring semester science, one possible flowchart could complete the themes and concepts started in the fall as noted in Figure 6.

Note that SAPA lends itself to short, integrated units of one or two weeks duration, whereas SCIIS is appropriate for semester-long integrations.

For school systems that do not operate with either of these aforementioned science programs, during each year, the program generally includes study of each of the elements listed in Figure 3. A teacher may choose a theme or an invention as the starting point. The process of integration is as follows.

First, examine the skills of both science and social studies. Then, note the concepts and broad content that students are expected to understand at the end of the year. Choose a theme or invention from concepts and/or content of one of the two disciplines. Brainstorm (preferably with students) to discover connections to other concepts and content. Discover what students want to know about each of the connections they make. Organize your connecting materials into a logical instructional sequence. Develop lessons that teach and apply all appropriate skills and respond to student generated questions.

What follows is an example of that process. In third grade, in one school system, students learn about electromagnetism (Montgomery County Public Schools, 1981). The next year they learn about sound and light. Both science and social studies emphasize the skill of communication along with other skills. The web of connections appears in Figure 7

In developing an integrated unit based on these content areas, I chose as my central focus, communication. I started with the discovery of the relationship of electricity and magnetism and the development of the electromagnet by Faraday, thus reaching back to third grade content. From there, the students examined two forms of communication that were developed using the electromagnet: the telegraph and the telephone. They studied electromagnets and experimented with them. They also experimented with creation and transmission of sound. They did research on three historical figures involved in these technological developments (Samuel F. B. Morse, Alexander Graham Bell, and Thomas Alva Edison) and discovered that there were at least two Black scientists involved in these or related discoveries: Lewis Latimer and Granville Woods. Students studied their roles in the history of technology. They learned about patent laws and the roles of Bell and Edison in the development of the telephone. Then they talked about the politics of laying the telegraph cable from Washington to Baltimore in 1843 and about the topography of the land over which the cable traveled. They developed and used mapping skills to plot the best course for the cable, considering the Piedmont area. Finally, students discussed how humans make sound and how it is transmitted and received, as they considered the elements needed in a telephone besides the electromagnet. They concluded by doing several experiments on sound. I could go much farther, but the purpose here is to show the process of integration. The content connections are always there. What is important is making sure the skills are taught and applied and that the students come to understand and develop the appropriate concepts.

Three methods for integrating curriculum have been presented above. All involve careful consideration of skills, concepts and broad areas of content. These methods could be used by curriculum experts or by the classroom teachers who will use the resultant lessons. My preference is to see teachers do their own curriculum development in response to the interests of their own students. It is difficult to develop a curriculum at the district level that is relevant to the diverse students whom the schools are currently educating. It is creative and exciting to develop and teach one's own curriculum to interested, involved students.

response to the interests of their own students. It is difficult to develop a curriculum at the district level that is relevant to the diverse students whom the schools are currently educating. It is creative and exciting to develop and teach one's own curriculum to interested, involved students.

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Science	Social Studies	Language
Observing	Observing	Observing
Using Space and Time	Map and Globe Chronology	
Using Numbers		
Measuring		
Classifying	Organizing Data Outlining Note Taking	Organizing Data Outlining Note Taking
Communicating	Arguing Writing Reporting Following Directions	Using Voice and Body Messages Writing Reporting Listening
Inferring	Inferring	Inferring
Predicting	Predicting	Predicting
Controlling Variables		
Defining Operationally		
Interpreting Data	Analysis Synthesis Evaluation Seeking Cause and Effect	
Hypothesizing	Hypothesizing	
Experimenting	Application Gathering Data Using References	Researching Using References
	Valuing	

Figure 1: The Process Skills of Science, Social Studies and Language Arts

SCIENCE	**AREA**											
					SOC.	STUD.				LANG.	ARTS	
SKILLS			HIST	GEOG	ECON	GOVT	SOCIO	*SPELL*	*GRAM*	*HAND*	*SPEA*	*WRIT*
Science	Social Studies	*Language*										
Using Space	Map and Globe											
and Time	learn direct.											
	earth, sphere											
	locating place											
	distance											
	elevation											
	grid skills											
	distortion											
	time											
	days, months											
	seasons											
	time sequence											
Use Number												
Measuring												
Observing	Observing	*Observing*										
		listening										
		seeing										
		smelling										
		tasting										
		touching										
Classifying	Categorizing											
	Organize Data	*Organize Data*										
	Outlining	*Outlining*										
	Note Taking	*Note Taking*										
Communicat	Arguing	*Using Voice/*										
		Body Message										
	Writing	*Writing*										
	Reporting	*Reporting*										
	Follow Directs	*Listening*										
Inferring	Inferring											
Predicting	Predicting											
Hypothsize	Hypothesize											
Experiment	Application											
	Gather Data	*Researching*										
	Use Refs.	*Use Refs.*										
Control Var.												
Define Oper.												
Interpret Da	Analysis											
	Synthesis											
	Evaluation											
	Seek Cause/											
	Effect											
	Value											

Figure 2: Teacher Checklist for Skills and Content

Science	Social Studies	Language
Geology	History	Writing
Atmosphere	Geography	Speaking
Cosmos	Economics	Grammar
Plants	Government	Spelling
Animals	Sociology	Handwriting
Human Body		
Matter		
Motion		
Energies		
Machines		
Environment		
Ecology		

Figure 3: The Content of Elementary Science, Social Studies and Language Arts

Controlling Variables Process

1. Recognize all variables.
2. Control all variables you wish.
3. Manipulate one variable.
4. Observe the responding variable(s).
5. Record data.
6. Design and carry out experiments holding different variables constant.
7. Hypothesize about effects of manipulating different variables.

Combines Inquiry Training Model from Models of Teaching and SAPA.

Figure 4: Application Steps for Controlling Variables Skill

LANDFORMS
NATURAL RESOURCES
using space and time
REFERENCE OBJECTS
RELATIVE POSITION
experimenting
controlling variables
interpreting data
CLASS MAPS
SCHOOL MAPS
COMMUNITY *MAPS*
STATE *MAPS*
RELATIVE MOTION
SHADOWS ON PLANES
SHADOWS ON GLOBES
inferring
TIME OF DAY
CLIMATE
PRODUCTS
PHOTOGRAPHS
MOTION PICTURES
AERIAL PHOTOGRAPHIC MAPPING IN MARYLAND
communicating

LEGEND
SOCIAL STUDIES CONTENT
social studies skills
SCIENCE CONTENT
science skills

Figure 5: Example of Integration of Fourth Grade Social Studies and SCIIS Module of "Relative Position and Motion"

- AERIAL PHOTOGRAPHIC MAPPING IN MARYLAND
  - EASTERN SHORE OF THE CHESAPEAKE BAY
    - *ENVIRONMENT MODULE*
      - GOVERNMENT
        - POLITICAL CHANGE
          - THE BAY WHEN MARYLAND WAS FOUNDED
            - *THE BAY TODAY*
              - HISTORY OF GOVERNMENT

LEGEND
SOCIAL STUDIES CONTENT
social studies skills
SCIENCE CONTENT
science skills

Figure 6: Outline of Integration of Fourth Grade Social Studies and SCIIS Environment Module

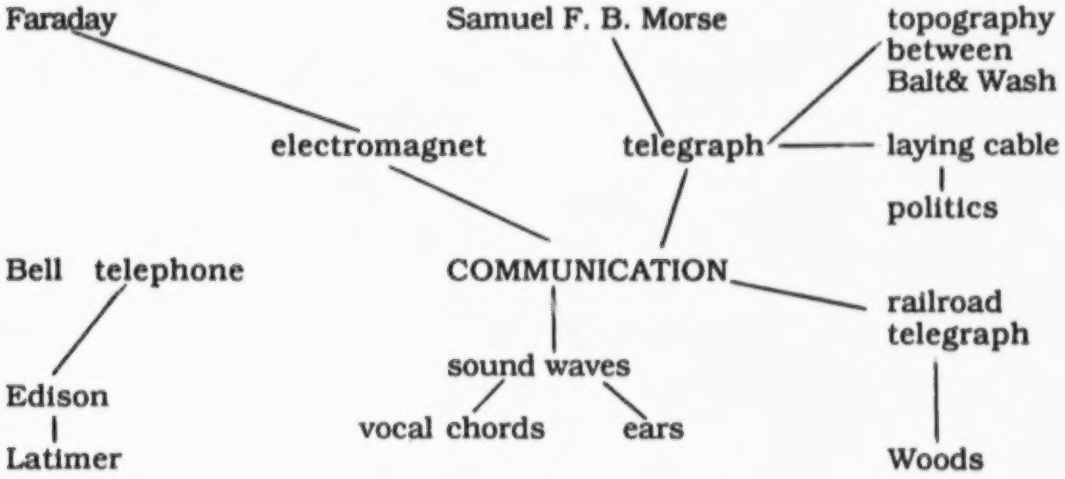
Faraday
Samuel F. B. Morse
topography
between
Balt& Wash
electromagnet
telegraph
laying cable
politics
Bell
telephone
COMMUNICATION
railroad
telegraph
Edison
Latimer
sound waves
vocal chords
ears
Woods

Figure 7: Sketch of a Web Showing Connections Between Science and Social Studies With Communication as the Focal Point

Logical Reasoning in Science & Technology

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Logical Reasoning in Science & Technology (LoRST) teaches scientific facts and principles along with critical reasoning to a target audience of grade 10 students of average (or above) academic ability. The science instruction takes place within the social context of drinking and driving, and within the technological context of the Borkenstein breathalyzer. Students learn scientific facts and principles in a way that connects the facts and principles with the everyday world.

LoRST is organized in a manner similar to other academic STS materials (Eijkelhof & Kortland, 1987; Hickman, 1984; Ziman, 1980). As depicted by the arrow in Figure 1, the book takes students from a socio-technological context into the domain of science concepts and skills. Although this science content is typical of grade 10 science syllabi, students view the content as helpful for making sense out of the socio-technological context provided in the introduction. The textbook ends in the everyday world of public policy decision making (a social issue related to drinking and driving), where students synthesize the book's scientific content with critical reasoning skills. The general content of LoRST and its "table on contents" are found in Appendices A and B.

[Figure 1 fits here.]

Specific critical reasoning skills are taught in a unit called The Logic Game, and then applied throughout the book. More important than the individual reasoning skills themselves, is the increase in students' predisposition to analyze, to question and to articulate a reasoned argument (Norris, 1989).

The Socio-Technological Context

In LoRST, the social issue of drinking and driving creates the need to know the technology of the breathalyzer, which in turn creates the need to know how science and technology interact with each other, and how they both interact with various aspects of society: the law, moral reasoning, and public policy. In this realistic socio-technological context, students learn scientific content such as mixtures, concentration, chemical reactions, photometry, electrical circuits, and the biology of body cells and systems. (A more detailed list of concepts is provided in Appendix D.) While the content is "driven by" the socio-technological context, the content is by no means watered down. When teaching the section on concentration, for instance, teachers find that their students achieve greater depth in their quantitative problem solving than normally expected.

The scientific content is continually scrutinized by the critical reasoning skills developed early in the book. Law cases involving drinking and driving or environmental controversies provide instances of scientific experts going at each other, head to head, using and abusing logical reasoning. In order to sort out the experts' conflicting positions in court, students must not only recognize logical and illogical reasoning, but they must rigorously apply conceptual details; for example, details about concentration, mixtures and equilibrium in the activity "Your Turn to Be Lawyer". Tenth graders are generally very eager to apply their scientific knowledge to real life situations. (A list of activities is found in Appendix C.)

Although the scientific content is often related to the theme of drinking and driving, it is also applied to other social issues of current importance; for instance, the issue of smoking, or the problems of toxic chemicals in the environment. The skill at making decisions (scientific, legal, moral, logical, and public policy) gradually develops with study and practice throughout the book. Learning in LoRST tends to be spiral in that regard.

The social issue of drunk driving requires particularly realistic decisions by students, rather than the more idealistic, hypothetical decisions sometimes associated with classroom exercises in STS.

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Adopting the Recommendations of the Science Council of Canada

Logical Reasoning in Science & Technology translates into practice new ideas about science teaching. In its 1984 report Science for Every Student, the Science Council of Canada called for a renewal of science education. The report advised educators to teach scientific concepts and skills embedded in a context relevant to all students. In LoRST, for instance, solving concentration problems is carried out in the world of court cases on impaired driving, recipes, false advertising, toxic chemicals and farm fertilizers. The classification of mixtures is presented via the composition of blood and the technology of salad dressings. Electricity concepts are introduced to bridge the gap between atomic theory and household applicances familiar to adolescents (both male and female). As a result, science becomes more interesting and more meaningful.

The Science Council of Canada specifically recommended that:

1. along with scientific concepts and skills, students should learn an appreciation for:
    (a) authentic science -- the nature of science and scientists, including the way science generates and uses its knowledge,
    (b) technology in Canada,
    (c) the interrelationships among science, technology and society;
2. females should be particularly encouraged to pursue science, math and technology in school;
3. academically talented students should be challenged to reason critically and creatively in science;
4. student evaluation should concentrate on fundamental understandings and reflect the complete range of goals of science teaching, rather than focus strictly on the memorization of facts and the rote application of formulas.

Related to recommendations 1 and 3, LoRST has the following approximate time allocations:

- science concepts, principles and skills (65%)
- critical reasoning (10%)
- nature of science (10%)
- science-technology-society interelationships (10%)
- technology (5%)

Teachers alter these percentages depending on how much time they wish to spend on each aspect, and depending on the particular STS emphasis required by the provincial science curriculum.

Following upon recommendation 2, LoRST encourages female students to become involved in science. Consistent with the work by Jones and Wheatley (1988), the book offers a balance of socially traditional male and female contexts in which students learn and apply the book's content. For instance, by focusing on electrical technology familiar to females (for example hair blowere), LoRST encourages young women to pose in-depth questions about that technology, thereby encouraging them to find scientific explanations for why the familiar technology behaves as it does. In addition, the "jobs" columns found throughout LoRST describe career opportunities in science and technology in a way that encourages both young men and women.

Guided by recommendation 3, LoRST provides students with ample preparation for further science course work. The intellectual skills and background knowledge needed for success in university science and engineering courses are developed systematically in LoRST. Mathematical problem solving skills are emphasized. But in addition, written and oral language skills are developed explicitly. The requirement to express oneself clearly and logically in prose lends a rigor to LoRST not normally found in science courses. The more difficult intellectual skills associated with LoRST (for example, applying and interpreting scientific knowledge) tend to be demanding. Higher student motivation often compensates, however. The book was developed for average academic students; but for the academically talented, enrichment is offered for a number of topics.

In keeping with recommendation 4, LoRST makes the assumption that meaningful learning takes place in a number of ways: by active participation, by reflection, and by practice at transfering a scientific idea to an everyday context. Through participation, reflection and practice, students are expected to incorporate new ideas into their previous knowledge, or replace their previously held, commonsense misconceptions with more precise scientific conceptions. This process of active learning takes time and patience. The evaluation procedures illustrated in the teacher guide reflect this in-depth learning of the subject matter. Several of the suggested test items, for example, require transfer of the science content to everyday situations.

As a consequence to this "meaningful learning" objective, a significant proportion of the text's content comes out of students' answers to the questions posed in the text and activities. These questions often use the text's didactic presentation of material, or the data collected in the lab, as sources for analysis, reflection and extension. Thus, some of LoRST's content is actually found in the answers to the text's questions.

Goals

LoRST's ultimate goal is to significantly improve the scientific and technological literacy of students. Because literacy is the empowerment to interact meaningfully and reasonably with one's environment (Fleming, 1989; Hurd, 1988), LoRST trains students to construct their own meaning of their world related to science and technology. Teaching for scientific literacy in LoRST comprises a balanced approach among several dimensions (Hart, 1987):

(1) the interactions among science, technology and society
(2) the nature of science itself
(3) the key facts, principles and concepts of science
(4) the intellectual processes used when doing science
(5) the manipulative skills required for doing science
(6) the values that underlie science
(7) personal interests and attitudes toward scientific and technological matters.

Closely aligned with the goal of literacy is the goal of achieving critical thinking (Aikenhead, 1989; Byrne & Johnstone, 1987). LoRST encourages critical thinking by training students to construct their own logical reasons for events and to critically analyze the reasons of others. Authentic conflicts between scientific experts are studied in LoRST for four reasons: (1) as a method of honing critical reasoning skills; (2) as a way of understanding the sociology and epistemology of science (Ziman, 1980); (3) as an experience to learn or apply science content; and (4) as a forum for recognizing the interactions among science, technology and society. In an activity "Decision Making Simulation", for example, the fallacy of false cause is a topic of analysis when students sort out the conflicting positions between villagers and a manager of a plant that burns PCBs. The conflict comes down to a typical jousting between experts on two sides of the issue. In sorting out the positions, students must answer the questions: How did the scientific community gain the knowledge which the experts disagree over? and What is the status of that knowledge? Because students have had first-hand experience with the process of scientific consensus making in the earlier activities "Fast Swing" and "Why the Fizz", and because students have practiced the skill of finding unstated assumptions, students tend to be more critical of expert testimony. Students remember the subjectivity involved in their own scientific consensus making. Knowing the provisional nature of the expert's knowledge (as well as its inherent uncertainties), students evaluate more critically the positions espoused by the experts (McPeck, 1981). The PCB controversy also illustrates for students the complex interactions among science, technology and society.

Other Features

Although LoRST may not "cover" as many science facts as science courses which are dedicated to covering an encyclopedia of correct answers and showing the structure of a particular science discipline, LoRST content is learned in depth and with critical thought. Students are expected to construct their knowledge for personal use in their everyday lives, rather than memorize isolated bits of information for tests and course credits. Constantly students are asked: How do you know? What does it mean? How does it help you make sense out of ... ? Consequently, science topics in LoRST tend to receive an in-depth treatment.

Time is taken to ensure that students (1) apply ideas to the complex everyday world (for example, analyzing newspaper articles), and (2) achieve a firmer grasp of the topics (that is, engage in higher order thinking).

There are numerous activities integrated into LoRST. They are listed in Appendix C. Some are familiar labs with a new twist. Others are simulations. Some of the more topical activities are printed in the teacher guide. This arrangement gives the teacher control over which activities he or she would like to use, and allows the teacher to update the technology/society/environment material which relies on current information.

LoRST requires about 80 hours of instruction (a typical Canadian school year). There is a great deal of flexibility when teaching LoRST. A teacher can easily omit sections of the book, leaving time to introduce other STS modules required by the curriculum or of local interest to students. LoRST can serve as a framework into which other topics easily fit. Because LoRST trains students to reason logically and to make thoughtful decisions (decisions guided by explicated values and accurate scientific knowledge; Aikenhead, 1985), the instruction time in the other STS modules will likely be more effective or efficient if they follow LoRST.

There are many student activities integrated into the text. The activities range from traditional science labs, to analyzing the media, and making decisions on public policy related to science and technology. Print material from newspapers and pamphlets is included for specific activities. Many of the activities are structured so teachers can easily make choices, modifications or substitutions to fit their class situation. The community and mass media, rather than the textbook alone, are sources of information for students and teachers.

The development of LoRST followed a multistage sequence which took advantage of the classroom realism well known to teachers and students. First, the author wrote and taught draft # 1 in a local high school. Based on this classroom experience, the student text was modified yielding draft # 2. By initiating the project in a classroom setting: (1) the classroom materials evolved "in situ" (on-the-spot instruction) with grade 10 students, (2) the appropriate teaching strategies for a real classroom situation were identified (Aikenhead, 1988), and (3) the rough draft of the teacher guide was written. This second draft of LoRST was vetted in a field trial with volunteer teachers. Their classes were observed daily. Thus in collaboration with students and teachers, appropriate teaching strategies were tested and the student materials modified. For example, when a student clarified for a friend what a text question meant, this rephrased question was incorporated into the text. As a result of this closely monitored field trial, LoRST was polished into draft # 3. Next, draft # 3 was field tested and evaluated across Saskatchewan by the Department of Education. Teacher feedback resulted in a number of revisions to LoRST. The resulting material, student text and teacher guide, will be published by John Wiley of Canada by June of 1990. Logical Reasoning in Science & Technology will be one of the first STS academic textbooks to initiate the next decade of science teaching.

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APPENDIX A   Outline of the Text

Unit I.   SCIENCE AND THE LAW   (10 hours of instruction time)

Drinking & driving tragedies
Court cases on impaired driving
Making decisions (legal, scientific, moral)
Scientific decision making

[These topics create the need to know more about logical reasoning, the breathalyzer, science concepts, and decision making. The social construction of scientific knowledge is introduced in simulations of scientific consensus-making.]

Unit II.   THE LOGIC GAME   (18 hours)

Basic assumptions and values
Some rules of logic
Arguments in general
Deduction and induction

[Topics include: How do you know what is true? What are the rules for correct reasoning? What are common mistakes in logical reasoning? How do you apply all of this to science (e.g. the historical development of the concept of heat) or to everyday situations reported in the mass media (e.g. conflicts between epidemiology and etiology studies)?]

Unit III.   THE BREATHALYZER   (40 hours)

Science, technology, R & D
Mixtures
Concentration
Body respiratory system
Henry's law
Mechanics of the breathalyzer
Chemical changes
Photometry
Current electricity

[The sequence of these topics is defined in a natural way by the sequence of events in the breathalyzer. Quantitative problem solving dominates many of the sections. Hands-on activities involve students with the phenomena. The activities demand that students apply "The Logic Game." A significant amount of content is introduced in the student activities, rather than being presented in the text.]

Unit IV. HOW ALCOHOL AFFECTS THE BODY (6 hours)

Digestive system
Liver
Circulatory system (Equilibrium)
Brain
Cells
Risk assessment

[Through "The Fantastic Voyage" metaphor, students follow ethanol molecules around a body as ethanol is absorbed, distributed and eliminated. Biochemistry is introduced on a need-to-know basis. Molecular changes are correlated with behavior changes and breathalyzer readings. Quantitative and logical analysis continues to be applied to most topics. Activities involve collecting and analyzing survey data, discussing media clips, and scrutinizing research data.]

Unit V. DECISION MAKING (6 hours)

Types of decisions
Technological fixes
A decision-making guide

[Students work through simulations and case studies that require different types of decisions -- scientific, legal, technological, moral, and public policy -- and that require a rigorous application of the book's content. Thoughtful decision-making skills are emphasized.]

APPENDIX B *Table of Contents*

I. SCIENCE AND THE LAW

The Lindbergh Tragedy
Court Cases on Impaired Driving
Making Decisions -- Legal versus Scientific
Scientific Decision Making
    Reliable versus Accurate
    Subjective versus Objective

II. THE LOGIC GAME

Introduction
Basic Assumptions
Basic Assumptions, Decisions and Values
Some Rules of Logic
    Conditions for Truth
    Minding Your P's and Q's
    Negation
    And, Or
    Truth Rules
    Truth Analysis of Complex Combinations
    If/Then
Arguments in General
    Logical or Illogical?
    Common Invalid Arguments
        Fallacy of Equivocation
        Arguing in a Circle
        Fallacy of Arguing Ad Hominem
        Appeal to Authority
        Fallacy of Asserting the Consequence
        Fallacy of False Cause
Deduction and Induction

III. THE BREATHALYZER

Introduction
Robert Borkenstein
Science or Technology or R & D ?
Science and Technology

- Borkenstein's Breathalyzer
    - Mixtures
        - Homo or Hetero?
        - The Technology of Salad Dressings
    - What Does .08 mean?
    - Collecting a Breath Sample
        - Structure of the Body's Breathing Apparatus
        - Breathing and Respiration
        - Out of the Blood into the Alveolar Air
    - Analyzing a Breath Sample
        - Blowing into the Breathalyzer
        - Chemical Changes
            - Chemical Symbols
            - Chemical Formulas
            - Elements and Compounds
            - Speeding up Chemical Changes
    - Measuring a Breath Sample
        - Light Balance Adjustment: The Technology
        - Light Balance Adjustment: The Science
        - Knowing When Its Balanced
        - Electricity in the Breathalyzer: A Scientific Theory
        - Electricity in the Breathalyzer: A Scientific Law
    - Review

IV. HOW ALCOHOL AFFECTS THE BODY

- Introduction
- The Fantastic Voyage
    - The Digestive System
    - The Liver
    - The Circulatory System (Equilibrium)
    - The Brain
    - Body Cells
- Sobering Curves

V. MAKING DECISIONS

- Types of Decisions
- Technological Solutions
- A Guide to Making Decisions

APPENDIX C *Table of Activities*

1. The Lindbergh Tragedy
2. The Lindbergh Tragedy: A Second Look
3. Fast Swing
4. Why the Fizz?
5. The Law of Heating (and Cooling) Bodies
6. Detective Work With "And" and "Or"
7. The Case of the Phantom Heat
8. Invalid Arguments in Advertising
9. The Story of Heat: The Final Consensus
10. Decision Making Simulation
    - 10.1 The Rechem Controversy
    - 10.2 The Spiked Coke Case
    - 10.3 The Politics of Smoking
11. You Be the Breathalyzer
12. Research and Development
13. Experimenting With Mixtures
14. Your Turn to be Lawyer
15. Pushing Concentration to the Limit
16. Breathtaking Measurements
17. Building a Model of the Breathalyzer
18. Chemical Changes: What do You Think?
19. Lavoisier's Ghost Says Balance Your Chemical Equations
20. Seeing the Light
21. Exploring Electrical Systems
22. What Did Ohm Discover?
23. Technological Inquiries into Electricity and the Home
24. What Shall the Sentence Be?
25. Alcohol: How Much is Too Much?
26. How Alcohol Affects Behavior and Driving
27. Alcohol -- The Opiate of the People
28. Time to BAC Off
29. The Average Rate of Elimination of Ethanol
30. Under the Influence
31. Thoughtful Decisions
    - 31.1 No Right to Drive
    - 31.2 Whose Responsibility?
    - 31.3 Other Topics

APPENDIX D Concept Content

Unit I. SCIENCE AND THE LAW

premises/conclusion
general criteria for making legal, scientific and moral decisions
epidemiological and etiological investigations in science
reliability, accuracy
scientific hypotheses, laws and theories
period, cycle, solutions of gases in liquids
manipulated, controlled and responding variables
consensus, pragmatism
private science, public science
scientific values
subjectivity, theory-ladenness, craft, bias; objectivity

Unit II. THE LOGIC GAME

scientific basic assumptions and values
temperature change, specific heat capacity, $Q = Cm\Delta T$
truth conditions in science and technology
symbolic logic
truth rules for "and", "or", "if/then" statements
fusion, vaporization, latent heat
truth function analysis
logical arguments: soundness, validity
six fallacies of argument related to science and technology
cause/effect
deduction, induction
proof in science and technology
energy, kinetic molecular theory, heat and temperature, conservation

Unit III. THE BREATHALYZER

four aspects to technological literacy
forensic science
measurement uncertainties
prototype
science, technology, R&D and their interactions
general criteria for making technological decisions
mixtures:
  - homogeneous: solutions
  - heterogeneous: dispersions
    - suspensions
    - emulsions
    - colloids

miscibility and intermolecular attractions
kinetic molecular model of matter (application)
molecular technology
diffusion
concentration: weight/volume, volume/volume, weight/weight (ppm, ppt)
number/volume
% concentration
variables: responding, manipulated and controlled
solubility, saturation, supersaturation
body respiratory system: physiology, tidal volume, expiratory reserve,
vital capacity, corridor air

- Henry's Law
- in vitro and in vivo investigations
- mechanics and fluid dynamics of the breathalyzer, feedback system
- calibration
- atoms, molecules and chemical changes
- chemical symbols, formula, equations
- balancing equations
- law of conservation of matter
- elements, compounds
- catalysts, enzymes
- photo electric cell
- inverse square law of light intensity
- circuits, series and parallel connections
- voltage, amperage, resistance
- Ohm's Law
- current electricity
- atomic structure: protons, electrons, neutrons
- electrical power and energy
- standardization
- accuracy and reliability

Unit IV. HOW ALCOHOL AFFECTS YOUR BODY

- data analysis, statistically significant differences
- systems
- absorption, distribution and elimination in systems
- digestive system
- enzymes
- chemical energy
- circulatory system
- equilibrium
- neurons, neurotransmission, brain functions
- cells, membrane structure: lipids, protein, cholesterol
- cell respiration
- statistical probabilities
- data manipulation, fudging
- correlation versus cause/effect

Unit V. MAKING DECISIONS

- technological fix
- risk/benefit analysis
- public science values
- private science values
- thoughtful decision making

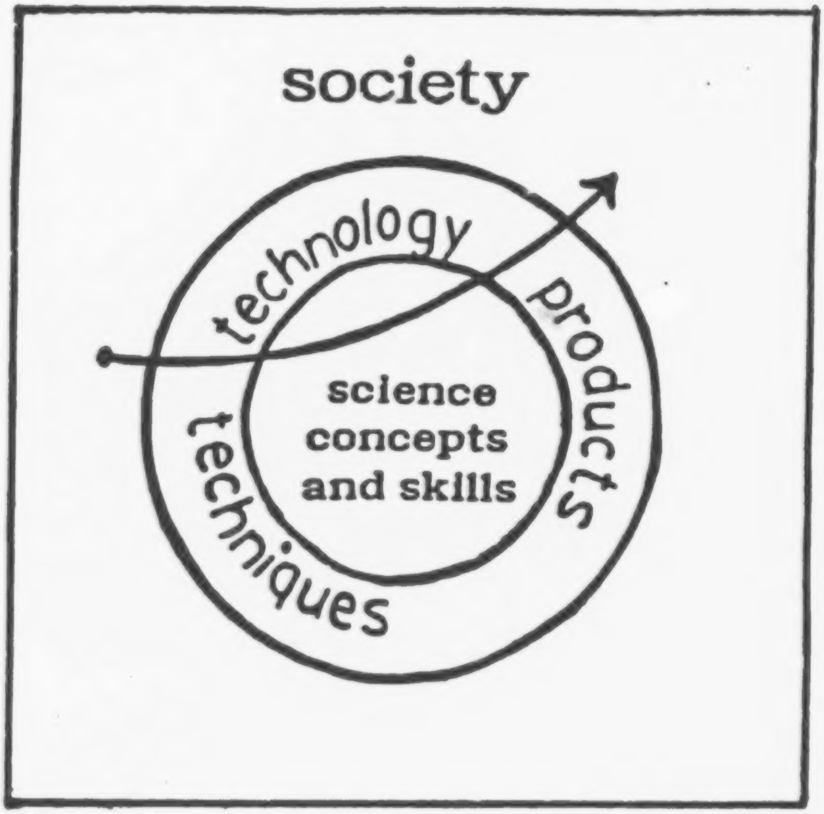
society
technology
products
techniques
science concepts and skills

Figure 1 A Schematic Illustrating a Possible Sequence for Organizing STS Material

(Modified from Eijkelhof & Kortland, 1987.)

HUMAN POPULATION GROWTH: AN S/T/S ISSUE

Deborah E. Brouse

Part of teaching science is helping students understand how science relates to social problems, both as a source of solutions and, sometimes, as a contributor to the problems. The unprecedented human population growth that has occurred in this century is largely a result of scientific and technological advances. The environmental impacts of population growth are also problems that science is being called upon to address. Thus the issue is a most effective focus for science/technology/society education.

It took approximately 3 million years for the world's population to reach 1 billion in about 1800. The number rose to 2 billion by about 1930, 3 billion by 1960, 4 billion by 1975 and 5 billion by 1987. The world population is expected to reach 6 billion by 1998. In other words, most of the world population size we have today was added in this century. Human numbers are growing at an unprecedented pace, and we are testing the limits of our planet as never before.

Advances in science and technology were major factors leading to this rapid population growth. Birth rates have not risen since the centuries before 1800, but death rates have dropped significantly worldwide. Medical advances and disease prevention through improved sanitation, inoculation and pest control have brought down child mortality rates and led to longer life spans. Advances in agriculture and transportation have led to increased food production and improved nutrition.

These improvements in people's quality of life are remarkable and laudable achievements, yet they have also created a new and major social problem: population growth so rapid that it throws off the delicate balance of nature. Air and water pollution, deforestation, thinning of the ozone layer, global warming, threats to biodiversity, soil erosion and depletion of many other natural resources are among the serious impacts of continuing growth in human numbers.

Because most of the population increase today is occurring in developing countries (over 90%), many Americans feel that they neither contribute to nor are affected by the problem. U.S. growth, however, places disproportionate demands on the world's resources. The next 100 million Americans, for example, are projected to consume more oil, gas and minerals than do all of today's 1.4 billion Africans and Indians. The 30 million people likely to be added to the U.S. population between 1988 and 2000 will create more solid waste and carbon dioxide emissions than the combined population increase of South America and Africa for the same period of time.

Today's students will probably see all of the environmental problems related to rapid population growth increase in their lifetimes. It is important that students understand how population, resources and the environment are interrelated and realize their individual decisions will contribute to the population trends and resource consumption patterns of the future.

How can population education be introduced most effectively in the science classroom? An abstract discussion of human population growth may not be as effective as a concrete, hands-on activity that involves the student physically as well as intellectually. One example is ZPG's "Stork and Grim Reaper" activity, in which the carrying capacity of a finite planet is demonstrated as the "stork," with a large cup, and "grim reaper," with a small cup, alternately add and subtract water (representing people) from a bowl ("Earth").

Another is ZPG's "Food for Thought" simulation. Students "populate" six world regions outlined on the floor, review regional demographic data (birth and death rates, growth rates, life expectancy, etc.), and distribute themselves in "urban" and "agricultural" populations, the latter confining themselves to "arable" land if possible. Some regions are much more densely population than others, and in some it is almost impossible to fit all the rural-dwellers on the arable portion of the land.

The students then receive concrete symbols of regional energy consumption (empty matchbooks), protein consumption (bread) and GNP (Hershey chocolate kisses), and respond to the inequities as they see fit. Often the results are demands for foreign aid, illegal immigration to other regions, or even war. There may be revolts by "citizens" against regional leaders who do not have sufficient resources to share with all their people. Sometimes leaders refuse to allow people from other regions to immigrate, or they let them in but will not allow them to share the region's wealth. Occasionally region leaders spontaneously offer foreign aid in hopes of stemming immigration pressures.

After the simulation, the teacher leads a class discussion of what happened: "Do any of these things happen in the real world?" Students may be asked, "What difference does it make to an American?" or "How will it affect Americans if Asia's population doubles in the next 36 years, as projected?"

ZPG, Inc. offers dozens of hands-on population education activities in classroom-tested teaching materials for grades K-12. ZPG also presents population education training workshops for teachers through conferences, inservice programs and teacher education classes nationwide. For further information, contact the author:

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Critical Thinking, Literary Criticism, and Concept Mapping: Tools for Teaching STS Courses

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Introduction

There is a special challenge in teaching Science, Technology and Society Courses. Specifically, the "Interdisciplinary" aspect of STS courses requires teachers to depend on textbooks for presenting information outside their own area of expertise. It is difficult for instructors to know the characteristic structure, leading ideas, and methods of inquiry across all the separate disciplines that create an STS focus.

For the students in STS courses, the challenge is more direct: They must be able to read the textbooks in a meaningful way. My own teaching experience supports the conclusion drawn from a wide range of educational literature regarding the FIRST OBJECTIVE of any course, namely, that each of our courses must be Literacy Courses. To enhance students' reading ability, they must produce written evidence that they understand what they are reading, that their reading results in meaningful learning. Meaningful learning is used in the same way that David Ausubel defined it: Meaningful learning occurs when new material can be related in a nonarbitrary (cf. rote) and substantive (cf. nonverbatim) manner to what the learner already knows and that the learner wants to learn the material in this fashion.

In order to implement this PRIME OBJECTIVE, course assignments and activities must take into account that today's students are visually, not verbally oriented. Students of the 50's were the last of the paper-trained, verbal, radio-listening, letter-writing generation. Today's students are icon or image oriented. They are a pictorial, visual, tv-watching, telephone-using generation.

The challenge is clear: How can we create learning environments (a good definition of teaching) for today's "visual" students when much of WHAT we teach in our STS courses is still found in books, books where the students can understand the words but not the meaning?

Three Useful Tools

There are three useful tools to improve student's writing assignments based on the course reading. These tools include:

1. Literary Criticism Methodology
2. Critical Thinking Guidelines
3. Concept Mapping

The tools can be "taught" at the initial class session, using the first several paragraphs of the textbook as specific examples.

The instructional setting of a specifice course provides a background for describing each of the tools.

The Instructional Setting

The example I would like to share with you is from a course taught in a graduate environmental education program for elementary school teachers.

The course was to provide a world-view of environmental issues. The textbook selected for the course was "State of the World-1987" (Brown, l. and others). The text had 11 chapters dealing with the major issues of the environment. For purposes that will become clearer later, each of the 11 chapters had an average of 83 paragraphs and 4 factual statements per paragraph, a total of 3652 semantic units.

Specific Course Objectives

In addition to the Prime Objective, the course had two additional objectives:

1. To help the students, as adults, to cross a perceptual threshold with valid information for the state of a sustainable worldwide society.

2. To help them, as teachers, translate important ecological ideas into valid curriculum exercises for children.

In addition to the teaching tools helping students meet the course objectives, one other important outcome was described by the students in the course evaluation: The tools helped the students identify areas of their own ignorance.

Tool Application

The raw material for using the tools is the paragraph. As an example, here is the first paragraph of information from chapter 1 of the text "State of the World-1987).

> "Daily news events remind us that our relationship with the earth and its natural systems is changing, often in ways we do not understand. In May 1985, a British research team reported finding a sharp decline in the level of atmospheric ozone over Antarctica. Verified by other scientists, the discovery of this "unanticipated "hole" in the earth's protective shield sent waves of concern throughout the international scientific community. A thinning ozone layer would allow more of the sun's ultraviolet radiation to reach the earth, causing more skin cancers, impairing human immune systems, and retarding crop growth."

Tool 1: Literary Criticism

The basic task in literary criticism is to understand the individual words of the text. For our purposes, the students followed a 3 step procedure:

A. To un-package the information in the paragraph, students wrote out (in their own words) the simple declarative statements contained in the paragraph.

In this example, there were four such statements:

1. There is a sharp decline in the level of atmospheric ozone over Antarctica.

2. Ozone is the earth's protective shield.

3. A thin ozone layer allows more of the sun's ultraviolet radiation (UVR) to reach the earth.

4. UVR causes skin cancer, impairs human immune systems, and retards crop growth.

B. The key words (mostly concepts) in these 4 statements were used to construct a PEOPLE -PLACES -THINGS Matrix:

People	Places	Things
-----	Antarctica	atmospheric ozone
		ultraviolet radiation
		skin cancer
		human immune system

C. Dictionaries, Maps, Almanacs and other resources are then used to relate:

--PERSONS to their historical/cultural context.
--PLACES to their geographic context.
--THINGS to "basic" dictionary meaning.

As an example, "ANTARCTICA" would generate the first PLACE fact sheet. Students described this land mass by indicating its location, comparison to other continents, size, history, recent happenings, etc.

Tool 2: Critical Thinking

Critical thinking skills include the ability to do the following:

. Differentiate fact from opinion.
. Recognize author bias.
. Determine cause and effect relationships.
. Draw Logical Conclusions.
. Make judgments.

Students applied these skills to various paragraphs in the textbook by marking specific sentences as instances of fact-opinion differentiation, author bias, etc.

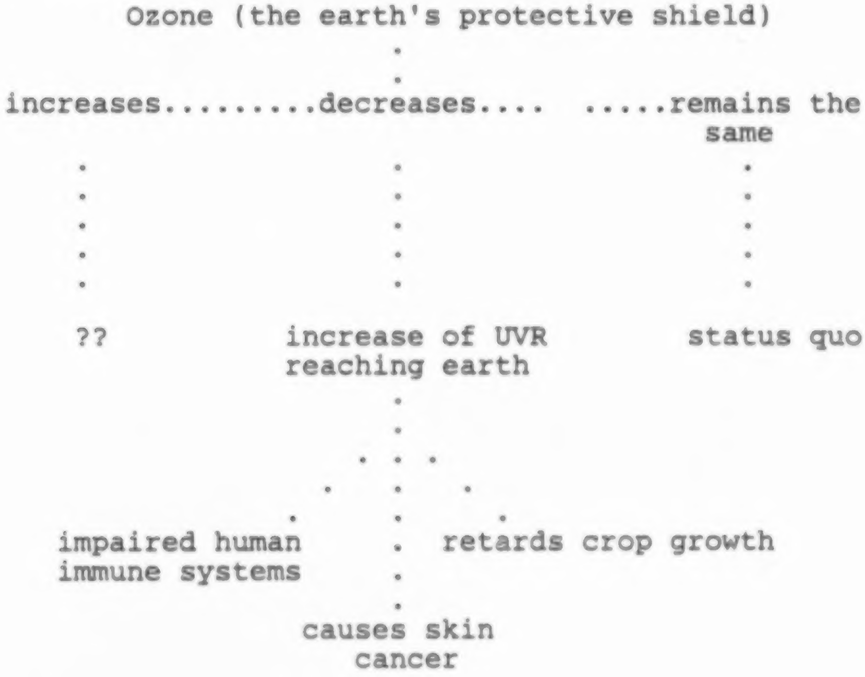
Tool 3: Concept Mapping

Concept maps are defined as visual road maps showing some of the paths by which concepts are connected.

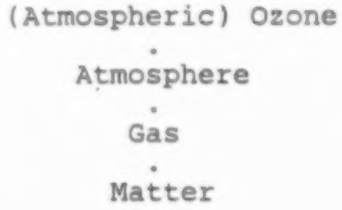
Concept maps are hiearchical displays of relationships. Learning proceeds most easily when new concepts are subsumed under broader, more inclusive concepts.

(The work by Novak and Gowin greatly expands the details of concept mapping).

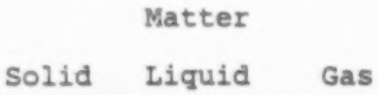
Here is a first-level concept map of the factual statements derived from paragraph one:


Ozone (the earth's protective shield)
increases
decreases
remains the same
??
increase of UVR reaching earth
status quo
impaired human immune systems
retards crop growth
causes skin cancer

A second-level concept map is constructed by "building-back" from any one of the concepts to a more-concrete expression of relationships. This building-back towards the datum plane from the abstract-conceptual level provides a powerful mechanism for testing one's own stability of "knowing". As an example (and using dictionary definitions) we produce this sequence of relationships:


(Atmospheric) Ozone
Atmosphere
Gas
Matter

This level of mapping then might look like this:


Matter
Solid
Liquid
Gas

Some Concluding Remarks

One of the most important functions of school learning in STS or any course is to foster cognitive learning. Concepts are the most important aspect of cognitive knowledge. By definition, concepts are regularities in events or objects designated by some label. The task for students is to learn the meaning of the labels (and not just the label for the concept). There are tool by which students can be helped to acquire the meaning of concepts in any field. Three powerful tools are literary criticism, critical thinking, and concept mapping.

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MathConn 89 - A Mathematics Awareness Day

Regina Baron Brunner

INTRODUCTION

In May 1988, a group of educators from grades K-12, school administrators, college professors, and representatives from business and industry met in a "brainstorming" session at Cedar Crest College in Allentown, Pennsylvania. The outcome of this meeting was the birth of a local network in the Lehigh Valley area of East Central Pennsylvania. This support network has as its purpose the encompassing goal of creating in the future a math center for research, teaching, and learning.

MathConn at CCC (Cedar Crest College) developed in response to a need in current society to address the problems of today's present and future teachers and those of today's students. The schools in cooperation with business, industry, and the community as a whole must encourage mathematical growth and interest at all levels for the United States to upgrade its mathematics education programs. The National Research Council, an arm of the National Academy of Sciences and the National Academy of Engineering, released a report entitled "Everybody Counts" on January 26, 1989. This report states that mathematics education in the United States needs major reforms to improve math achievement.

High technology cannot afford to overlook the power it possesses to encourage youngsters to plan for a career in math-related fields. For example, are women being used to their full potential? How many women are employed in math-related fields? What percentage of women have Ph.D.s in such fields?

Edward A. Connors, professor of mathematics at the University of Massachusetts at Amherst, has become a spokesperson for the urgent need for more math majors. In the October 23, 1988 issue of Parade Magazine, Dr. Connors listed some disconcerting facts concerning this disturbing lack of interest in mathematics. Some points noted were the following:

> Fewer and fewer U.S. citizens are interested in advanced mathematics.
>
> Last year marked a 20-year low in the number of graduate math degrees earned by Americans.
>
> Between July 1986 and June 1987, fewer than 400 U.S. citizens were awarded doctorates in math. During that period, 51% of the math doctorates awarded in the U.S. were earned by foreign students studying here.
>
> Many of the teachers do not realize that if they fail to interest a student in math by the sixth grade, they've lost the student forever.

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> Parents should consistently encourage their children, particularly girls, to consider math as a career possibility.

In the January 11, 1989 issue of The Chronicle of Higher Education, Dr. Connors enumerates more startling facts concerning this worrisome, declining interest in mathematics.

> In 1988, for the second year in a row, universities in the United States awarded fewer than 400 doctorates in mathematics to Americans....
>
> The combined total for 1987 and 1988 is less than the total for any one year in the late 1960's or early 70's. The National Science Foundation's reports show, for example, that more than 1,000 American citizens earned doctorates in mathematics annually from 1970 to 1972.

Some remedies suggested by Dr. Connors are:

> Parents and educators must raise the level of what we expect our young people to accomplish in mathematics....
>
> We should dispel, once and for all, the nonsensical notion that mathematics is a man's game. The appearance of more women in mathematics in recent years is encouraging, but we need to do better in publicizing their successes....
>
> We need to provide more and better information on careers in the mathematical sciences....
>
> Finally, we need to re-establish respect for the teaching profession in general.

PLANNING STAGE

The impetus of MathConn at CCC stemmed from considering questions such as those listed above before they appeared in print. In June 1988, the Planning Committee started to shape the day despite no source of funds except that from Cedar Crest College. We contacted various book publishers and they pledged support.

To begin in a small but manageable way, our network chose as target groups 7th and 8th grade girls and their mathematics teachers from 95 middle and junior high schools in the surrounding five county area. MathConn at CCC felt that these students have not chosen a field to pursue at this point in time and that mathematics interest may not have waned yet. Since Cedar Crest is a women's college, it is an ideal place to foster, to encourage, and to publicize an interest in mathematics for girls.

At the June session, the Planning Committee reviewed the Sonia Kovalesky High School Mathematics Day, a program for high school women and high school teachers developed by the Association for Women in Mathematics. Their information packet was extremely helpful as a starting point for the project.

Because much mathematics is learned by talking and by manipulating structures, we decided to reward and to encourage such behavior by having a Discovery Problem Session where students would work in teams and solve open-ended problems or ones with no solution. The school administrators did not want a competition between schools. At their suggestion, the decision was made to place students into teams mixed across schools and to emphasize that the problem session required no preparation beforehand.

As has happened so very often along the way, the group found printed materials to support the decisions that they had made - after the fact. The NCTM "Curriculum and Evaluation Standards for School Mathematics" available in March 1989 will stress communication in mathematics. At the planned problem session, students will communicate mathematics with each other verbally and to a group of teachers in written form. So, our ideas again preceded the recommendations to be printed by NCTM.

In order to publicize the success of women in mathematics at the present time, the Discovery Problem Session was named in honor of Dr. Mary Ellen Rudin, mathematics professor at University of Wisconsin-Madison. Dr. Rudin is a present day role model of both an enthusiastic teacher and a world-renowned mathematician.

In the summer of 1988, we structured the day and chose a name for the group. In September 1988, we grappled with a lack of funds. At the administrators' suggestions, the decision was made to charge a registration fee for students but not for teachers.

In the Winter 1989 issue of AMP-LINE, the American Mathematics Project quarterly, advice given concerning fundraising includes the following: "Try to get commitments from the school district for both release time for teachers and a cash contribution." Again, the group came to this decision before it appeared in print.

In September 1988, a letter explaining the planned day was mailed to 95 public, parochial, and private schools in Intermediate Units 20 and 21 (a five county area in East Central Pennsylvania). We were rewarded with a tremendous response. Enrollment was limited to 6 students and 2 teachers per school.

Presently, approximately 40 schools with over 200 students and 60 teachers are coming. One administrator on the team was overwhelmed by the response. To us, this proved that there is a need for such projects. Over and over again, we heard this refrain, "We want to help but we don't know what to do." A large problem is to bring such devotees together for the common good.

In December 1988, questionnaires were distributed to decide on the types of speakers to have for career talks and on the workshops and activities to plan for the teachers.

THE PLANNING COMMITTEE

The Planning Committee has evolved into a strong team. The use of the particular individual strengths of each member gives power to the team. The administrators have been invaluable in their many suggestions to assist with organizational skills and to help with gaining support for the network. One administrator suggested obtaining a keynote speaker for the teachers from the Pennsylvania Department of Education. Dr. Richard L. Kohr, educational measurement and evaluation supervisor, will talk about Pennsylvania's future mathematics testing\program.

The teachers in the group have served as "sounding boards" for ideas. They have suggested activities that match exactly the desires indicated by the surveyed teachers. Teachers do know exactly what they want and need. They need a place to convey these desires to those who can help.

The industry representative has also been invaluable. He has made contacts in business and industry not available to teachers, and he has pushed the group to dream beyond their wildest imaginings. He helped with funding and he contacted world-renowned women mathematicians to speak to the girls. MathConn 89 has received grants from Air Products & Chemicals, Digital Equipment Corporation (DEC), IBM, and Pennsylvania Power & Light. The keynote address speakers for students are Dr. Linda R. Petzold, group leader for the numerical mathematics group at Lawrence Livermore National Laboratory in California, and Dr. Lilian Shiao-Yen Wu, a member of the operations research staff at IBM's Thomas J. Watson Research Center in New York.

The college professors are always amazed at how much we learn at the monthly meetings from other members. We always are surprised at how all our bright ideas before the meeting are changed, modified, and refined at the meeting, and evolve into completely different concepts.

MATHCONN 89

The day evolved now consists of many varied events. Each girl will take part in the Mary Ellen Rudin Discovery Problem Session. Also, each girl will attend a panel discussion by women in math-related careers. Not so surprisingly, the hand-down favorite career choice was math teacher. This coincides with Dr. Connors' observation that "All too often a student says, 'I know that I can teach with a math degree, but what other options and opportunities are there?'" During lunch, the students will hear a talk about career opportunities in high tech companies, listen to a statistics talk with computer displays, or watch a VCR tape of computers in the next century. Hopefully, exposure to positive role models and the exciting world of current, vibrant math-related activities will encourage interest in mathematics itself and in math-related careers.

The day for teachers will be less structured with choices of workshops, hands-on displays, and discussions led by peers. The luncheon speaker will be the representative from the Pennsylvania Department of Education.

The final session will consist of evaluations to be completed by all participants, a talk about Dr. Rudin, a discussion of the solutions given by various teams at the Discovery Problem Session, and an awards ceremony for the best teams in various categories.

CONCLUSION

Somehow, somewhere, someone must change the tide. Mathematics and math-related fields are exciting but the enthusiasm must be spread to all students at all levels through an organized effort of interested persons aided by funds from business and industry. It can be started on a shoestring and a "sparkle in the eye" dream if the network builds upon two key structures; namely, a strong, trusting, collaborative ownership effort and an overabundance of enthusiasm.

If the team wants a project to work with their whole heart and soul, it will happen. They must be willing to shift emphasis when necessary and to listen to each other openly. Bending is an integral part of network growth. The evolved day that will be MathConn 89 is very different from the one imagined prior to the June 1988 session.

MathConn 89 has mushroomed into a spectacular day beyond any teacher's wildest dreams. Hopefully, others will be encouraged to try to make their bright ideas into reality also. Such "grass roots" movements will lead math educators into viable, workable solutions to address and to relieve the perplexing current crisis in math education.

EPILOGUE

MathConn 89 was a smashing success for both teachers and students. The evaluations were extremely encouraging. The Joint Policy Board for Mathematics has selected MathConn 89 as an example to publicize similar events nationwide for Mathematics Awareness Week in 1990. MathConn 90 is scheduled for April 4, 1990.

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'WASTE MANAGEMENT': ENVIRONMENTAL EDUCATION IN SCIENCE

Arend Brunsting, Frans van der Loo and Obe de Vries

1. Introduction

Awareness about the increasingly poor state of the natural environment is now widespread in Dutch society. As a result, the importance of environmental education is acknowledged and efforts to integrate environmental education in the school curricula are intensified. One of those efforts is made by the Project on Environmental Education in Secondary Education (Dutch acronym: NME-VO). This project, which is financed by the government, develops a curriculum and teaching materials on environmental education for the school-subjects science and geography.
In this paper we describe
- how efforts to implement environmental education in the school-system have become successful
- in which way the project NME-VO attempts to integrate environmental education in the current curricula
- which features of environmental education are reflected in the teaching unit 'Waste Management'.

2. Implementation of environmental education: the political process

In the near future all students in junior secondary school (12-15 year) will be exposed to environmental education in various school subjects. Moreover, the national project NME-VO has started since 1986 to realize the integration of environmental education in science and geography. So, the implementation of environmental education in secondary education is on its way. How did efforts to achieve this become successful?

Three developments are important in this respect:
a. 'Environment' has become a *political priority*. From 1970 onwards discussion on environmental issues intensified. The Ministry of Environment was established in 1971 and environmental policies were developed. Still, the symptoms of the bad state of the natural environment become increasingly visible and environmental awareness increased. Since the publication of an official report on the state of the environment (Care for the Future, 1988) environment has become a top political priority. In the official environmental policy environmental education is considered as one of the policy instruments, as it might increase public support and awareness.
b. A strong *network of environmental (non-governmental) organisations* has been developed, partly financed by the government. The main functions of this network are to influence governmental environmental policy and to promote and practice environmental education, both inside and out of school. The organisations started to develop teaching materials on environmental issues and gradually penetrated the school system. The organisations also generated a political lobby on environmental education. A relations-network with Members of Parliament and civil servants has been created and proves to be of great value.
c. In science education a development towards *STS-education* took place. A major impetus to this development was given by the PLON-project on physics education. This project developed a physics curriculum consisting of thematic units, in which physics is taught in a technological and social context. Gradually the idea of teaching science in a wider context was accepted. From this point of view environmental issues are considered as a context of science education.

These three developments came together in 1985 and gave birth to the *project NME-VO*. The environmental organisations had experience in developing teaching materials on environmental issues and looked for implementation in secondary education to a larger extent. The PLON-project had experience with developing science teaching materials in a broad context. And Departments were willing to spend money on environmental education.
During the project NME-VO the cooperation between these institutions intensified and the institutional platform for environmental education was strengthened.
In the meantime a bill on environmental education was prepared by the Departments of Environment, Agriculture and Education and discussed in Parliament in 1987. Influenced by the political lobby of the environmental network, one outcome of this discussion was that more Departments

should pay attention and allocate funds to environmental education. This decision will significantly increase the budget for environmental education over the next few years.

Thus, an increase in the efforts on environmental education, both in and out of school, is to be expected in the near future.

Yet another development is the *reconstruction of junior secondary education* (12-15 year) towards a single national curriculum. In 1986 committees were formed to formulate statements of attainment for each school subject. A political lobby by the environmental organisations towards both the Department of Education and the Parliament resulted in several committees receiving an instruction to include environmental aspects in the statements of attainment. In the meanwhile a blueprint for statements of environmental attainment was formulated by the NME-VO organisations. By membership of these committees and/or by reviewing their drafts the environmental organisations and the project NME-VO have effectuated that the statements of attainment, as formulated for the subjects biology, physics/chemistry, technics, geography, history and economics, actually pay attention to environmental aspects.

3. Implementation of environmental education: the project NME-VO

The main aim of the project NME-VO is to *integrate environmental education in the subjects biology, physics, chemistry and geography* (science is split up in separate subjects, also in junior science education) at all ability levels of secondary education. Non-governmental organisations already had developed a lot of teaching materials on environmental issues, but experienced that implementation efforts failed. One of the reasons for this might be that the materials had a general character and did not fit into the existing school subjects. As there are national examination syllabi, teachers feel that they do not have much spare time for these 'extra' teaching materials. Therefore the project NME-VO started to develop teaching units, which correspondend better with the current curricula of the school-subjects.

THE PROJECT NME-VO:

- **means Environmental Education in Secondary Education**
- **is a cooperation between environmental NGO's and educational institutions**
- **is financed by the Departments of Education, Agriculture and Environment**
- **integrates EE in biology, physics, chemistry, geography**
- **for 12-16 years old students, all ability levels**
- **main activities:**
  - **development of a curriculum on EE**
  - **development of teaching materials**
  - **research on students' conceptions and learning effects**
  - **try-out in 9 trial-schools**
  - **implementation acivities**

TEACHING UNITS:

title	subjects	form	age-group	ability-level
wetlands	ge/bi	1	12-13	all levels
meat	ge/bi	2	13-14	all levels
fuel	ch/ph/ge	3	14-15	high
traffic noise	bi/ge/ph	3	14-15	average
pesticides	bi/ge	3	14-16	low
waste management	ge/bi/ph/ch	4	15-16	high

4. Characteristics of environmental education: the teaching unit WASTE MANAGEMENT

Essentially, what environmental education stands for is to achieve environmental awareness. We conclude that it is essential that *pupils gain knowledge and skills which enable them to take into consideration the quality of the relation between man and environment in their mental and practical activities.*

The teaching materials of NME-VO therefore focus on *decision making* situations of a personal or societal nature with environmental aspects. Like most STS-education the approach is based on *issues*. The units are *adapted to school subjects and current curricula* and open with respect to behaviour. These features are elaborated below and illustrated by the unit *"Waste Management"*. Waste Management is designed for age group 15-16, high ability level, and for the subjects geography, biology, physics and chemistry.

issues

The issues of the NME-VO units deal with situations of everyday life. We selected *contexts* which are relevant for pupils. Besides "waste", these are: residing, food, energy consumption, traffic, water use, consumer goods and recreation. Relevant science and geography contents and skills are presented for a better understanding of the issues: science and geography in an environmental context.

Environmental education not only deals with the natural environment. The *mutual relations between men and environment*, the *problems* in these relations and the ways *how to solve these* take a central position in our approach. To analyse these relationships we use a set of notions which characterise the significance of the environment for men at the one hand, and man's interventions at the other hand:

1. Significance: for (economic) use, for security and health and an intrinsic value of nature.
2. Interventions: pollution, depletion of resources and other interventions.

The issue of waste management was chosen because it offers ample opportunities to illustrate the model of the relations between man and environment indicated above. Moreover, the concept of "sustainable use" of the environment is a major theme in environmental education, and can be nicely illustrated by this issue. Waste management is of growing importance and a hot topic now in the Netherlands. All 4 disciplines of the project could contribute practically to the analysis of this issue.

decision making

All NME-VO units deal in some way with "thoughtful decision making" and are structured around a *key question*. In this way environmental education, as in other kinds of STS education, broadens the aim of science (and geography) education towards enabling the student to cope with situations in everyday life, as a consumer or as a citizen.

In the teaching units which we have developed for the age groups 12-15, emphasis is put on personal valuations and decision making situations of a personal nature. The unit "Waste Management" is meant for high ability pupils, age group 15-16, as part of their pre-university education. For this group the emphasis is on decisions of a societal nature.

In the unit an "Environmental Impact Assessment" (E.I.A.) procedure is followed. This is a relatively new and important procedure in the policy of the authorities to structure decision making in planning activities with important environmental consequences. The E.I.A. presents data, valuations, discussions and decisions in a realistic framework and students learn how these decisions are made in reality. Scientific arguments play an essential role in this procedure.

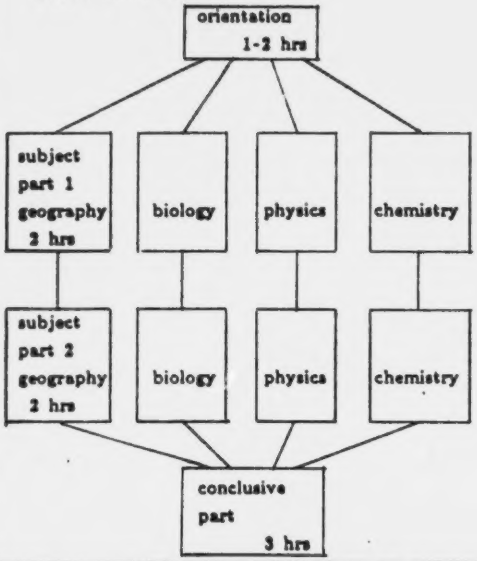
The role of the school subjects (scientific disciplines) in social decisions can be elucidated in this way.

outline of the unit

The unit "Waste Management" deals with the management of household refuse of an imaginary average Dutch province. The case and the key question are presented in the orientation part.

The key question to be answered is: "What is the best way to manage household refuse?" Pupils have a limited scope on the problem of waste. They tend to consider it mainly as a pollution problem. More aspects of the problem are presented: area planning, depletion of minerals and fuel and affection of biotopes. These aspects should be taken into consideration also in the valuation of the problem. The management is to be planned for the next 20 years. Four possible alternatives are presented: landfill, burning, central separation of components plus recycling and source separation plus recycling.

UNIT STRUCTURE



- o key question: what is the best way to manage household refuse?
- o outline of alternatives: landfill, burning, central separation + recycling, source separation + recycling
- o background information: waste, waste management and environmental aspects
- o analysis of Environmental Impact Statement; 4 alternatives, 12 environmental aspects and completion of statement
- o role play: decision making on the key question

The key question is divided into more specific questions in the subject parts. In the biology lessons, for instance, the question is asked "which impact has each waste management alternative on flora, fauna and human health from the viewpoint of pollution?" However, before answering these questions a bit of "expert" knowledge is offered (see next paragraph). With this knowledge, and guided by a set of more specific questions, small groups of pupils must find their way in the Environmental Impact Statement. This statement is kind of a resource book of data and expected effects.

Before the conclusive part all information and evaluations are collected and the Environmental Impact Statement is completed by the completion of the form below.

How do you judge a waste management alternative, if you take into account:	landfill	burning	central separation	source separation
depletion				
1. depletion of mineral resources				
2. depletion of energy resources				
3. depletion of forest resources				
4. depletion of soil fertility				
pollution				
5. effects of pollution on flora and fauna				
6. effects of pollution on human health				
7. effects of pollution on land use				
affection				
8. effect of occupation of area and disturbance on flora and fauna				
9. effect of occupation of area and disturbance on land use				
other considerations				
10. costs and benefits				
11. employment				
12. convenience to inhabitants				

In this form a judgment (first - least preference) is given on each management alternative for each (environmental or other) aspect. The completed form is distributed to all participants. Based on this survey the conclusive part can start. In a role play a public hearing is simulated. Political parties, special interest groups and the public discus on the best waste management. At the start and afterwards an opinion poll is organised. Finally the decision making process is reflected on and importance of the prevention of waste is stressed.

school subjects and current curricula
Integration of environmental education in school subjects and curricula is a major aim of the project NME-VO. Waste Management shows many features which relate closely to or are part of the current curricula. This is especially so in the subject parts (1), where "expert knowledge" is offered.

ITEMS RELATING TO THE SUBJECT CURRICULA

geography

- **urban, suburban and rural areas (and composition and volume of waste stream);**
- **allocation (of waste treatment installations) and coverage, threshold value, costs, enlargement of scale, central and source separation;**
- **occupation of area, land use and dispersal of pollution, emission dispersal pattern, deposition, inversion (atmosphere), seeping water, adsorbtion to soil.**

biology

- **biological processes in organic refuse: aërobic and anaërobic dissimilation, production of methane and compost;**
- **toxicity (of refuse), of heavy metals (esp. cadmium), accumulation of cadmium in the food chain, poisoning of nutrient cycles;**
- **effect of cadmium on tertiary structure of proteins (sulphur bridges), poisoning of ensymes, cadmium and health, accumulation in organs, no (adverse) effect level (NEL), acceptable daily intake (ADI), disease and symptoms.**

physics

- **energy costs of products, energy in glass refuse and total household refuse;**
- **direct and indirect energy costs, system definition and fair comparison;**
- **waste management and energy saving: reutilisation of objects, recycling of materials.**

chemistry

- **depletion of mineral resources, reutilisation of minerals and price, how to upgrade waste;**
- **pollution, problematic substances: mercury, cadmium; PVC and waste management, burning, detoxification, concentration, isolation, reutilisation.**

At this level of education not all subjects are compulsory for all pupils. The unit allows pupils to study some of the subjects and get information from the other subjects and viewpoints by means of the completed report which is offered at the beginning of the conclusive part.

5. Results

The unit has been distributed to 4 trial schools in December 1988. One school has started with it, and teachers and pupils appear to be interested and getting more and more involved in the complex and fascinating subject.

Preliminary data on this and the other schools will be available in August 1989. A major follow-up in 1990 is hoped for, but not yet supported by financial means. Meanwhile more ideas of how environmental education can be integrated in pre-university education are being generated and will hopefully be put into practice next year. The results of this will be communicated from 1990 onwards.

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IMPLEMENTING TECHNOLOGY EDUCATION

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WE CAN TEACH IT BETTER...TOGETHER

Two years ago, a chemistry teacher stopped by the auto shop to ask if I would give a demonstration on the operation of an air conditioning system to sophomore chemistry students. "Sure! What for?", I said with moderate suspicion. After all, how often do science teachers mix with shop teachers? The science teacher's response was the beginning of a new direction in the curriculum and perhaps a philosophy in our school towards Technology.

> We're studying the unit on phase change and the air conditioning system in the car does a great job showing a practical application. Your demonstration will make it easier for science students to learn science. (Bourey, April 1986)

The demonstration went well. Science students got a glimpse of the practical application of scientific theory that is common to the Industrial Arts lab. The students showed a renewed excitement for learning and a more positive spirit about science. Science students that would never have been exposed to technology were recognizing a new path to understanding science. Some students eventually enrolled in a technology class to complement their scientific and career goals. The chemistry teacher noted an improvement in student achievement. Cooperative teaching lessons were planned in physics with similar results. Science and technology complement each other.

Preliminary discussions were held with the Department Head of Science, the Vocational Director and the Associate Principal of Instruction to evaluate the curriculum possibilities. Constructive planning sessions led to the conclussion that chemistry and physics were equally suited candidates for cooperative studies in science and technology. The discussions led to a meeting of both Industrial Arts and the Science Departments. The Science teachers provided overwhelming support for Administrative consideration of the new coursework. Department Heads met as an Instructional Council and reviewed the course proposal with favor. Early in the fall of 1987, the Board of Education adopted two courses:

A) Technology of Chemistry
B) Technology of Physics

MORE THAN A TREND...

The enthusiasm about courses like Technology of Chemistry and Technology of Physics is not unique to local school systems.

> Where technology has been tried as a focus for school science, enrollments have increased, public support for the effort has grown, student test scores have increased, and, most important, student interest and motivation have improved. (Yager, 1987).

States are making educational investments in similar tech-science curricula. The State Board of Education, State of Illinois, has endorsed the curriculum development titled Principles of Technology, (PT for short). This fourteen unit study was prepared by the Center for Occupational Research and Development and covers science and technology issues such as force, power, energy, transducers, light, sound, and nuclear energy. PT represents a six million dollar investment in Technology Education. Colorado is home of Project Engineering, coursework that simulates engineering careers. Penn State is the pioneer in STS, Science, Technology and Society and center for STS studies. Ball State is the Center for Implementing Technology Education (CITE) and has been identified as the distributor of the Indiana Industrial Technology Education Curriculum guides.

In England, Science and Technology in Society, SATIS, has been providing science and technology instruction in a real life context since September of 1984. SATIS operates on the principle that our students will be living in a world dominated by the manifestations of science and technology. Relevant science and technology instruction is essential in the future.

> We are all born scientists, with an inate curiosity about the things around us, the materials that make up the world and about other living things. Some retain this curiosity all their lives, but others lose it - perhaps because the science they study is too esoteric, too academic or too far removed from their everyday lives and experience. (Holman, 1986)

Across the country, throughout the world, in junior high, in senior high and post secondary education, institutions are making a transition to tech-science. Technology of Chemistry, Technology of Physics, SATIS, Principles of Technology and like courses are more than just trends in an educational cycle. They are requirements of the future.

> By the time your students are 30 to 40 years old, technical knowledge will be their key to survival. (Wiley, 1988).

WHY DOES TECHNOLOGY OF CHEMISTRY WORK ?

Technology of Chemistry and Technology of Physics are unique from the ground up. Take a look at the mechanics of the schedule. Our district course description for Technology of Chemistry reads:

Technology of Chemistry
1 Year, 1 Credit, 3 Periods per Week
Prerequisite: Concurrent enrollment - Chemistry

The application of science (chemistry or physics) concepts and principles to technology will be examined. The student will gain a first hand understanding of the interdependence of science and technology. Problem solving from the technical viewpoint utilizing the student's scientific understanding will be stressed. Effort will be made to correlate the principles, concepts, and knowledge being studied in science class to current technology.

Students registered in the technology option must be concurrently enrolled in Chemistry. He or she will attend the Chemistry section seven periods per week; two days are scheduled as double period chem labs. Three days are scheduled for single period science lectures. Technology of Chemistry is scheduled for the remaining three periods to complete a double period block. The student attends Chemistry lab, 4 periods, Chemistry lecture, 3 periods, and Technology of Chemistry for 3 periods for a total of ten periods per week. Tech Chem students will be exposed to 30% more science related instruction for the year and receive a total of 3 credits. Technology of Physics follows a similar format. See Appendix B for a sample of a daily schedule.

Tech Chem works because the schedule fits our needs. Students must take an elective to fulfill an applied arts requirement. Students planning to attend selective universities need (will need) three lab science courses. Tech Chem and Tech Physics allow a student to fulfill a science or applied arts elective without overloading their schedule. Educators are concerned about the increasing pressures on students to take additional academic classes. Technology of Chemistry and Tecnology of Physics makes it easier for the college bound student to complete a rigorous 4-year academic plan and take a technology elective. This scheduling alignment provides the student with 3 credits in 2 academic periods. This approach is looked upon with much favor by administration, guidance counselor and parent. Show the science teachers and administration how technology compliments science and the academic program in your school.

Other advantages of the Tech-Science cooperative become obvious. As science and technology teachers work together, the list of benefits will expand.

A) Cooperative teaching for science and technology serves the needs of students at risk by enhancing achievement.

B) Students can more easily enroll in science and technology courses through reduced scheduling conflicts.

C) Students have more flexibility in their junior and senior years to take additional Science credit and/or Industrial Arts/Technology electives.

D) Technology of Chemistry and Physics complement the dual role in preparing students for higher education and careers by stressing problem solving.

E) Because of the Technology lab activities, Technology of Chemistry and Physics can help students with learning disabilities succeed in science.

F) Increased professional interaction between science and technology teachers will result. Math teachers may join the cooperative in future curriculum development. Program goals will be attained more effectively and completely.

Your school is unique. The items in this list of advantages may not all apply to your district. Specific instructional outcomes, daily schedules, graduation requirements, scheduling limitations and departmental personalities will effect the successful integration of technology education programs. It is very important to note that the Science Department must have some ownership in the curriculum. If you are power minded about who gives credit or territorial about what facility will the course be taught in, then you might as well not venture into Technology Education. The day of the isolated classroom is gone. Your mission statement should clearly identify that the purpose of Chem Tech or Physics Tech is to enhance student scientific achievement through technical-practical experiences.

Technology of Chemistry and Technology of Physics are examples of courses that fit a specific system and are ideally suited for a set of institutional goals. The course can be aimed at honors students as well as students in a basic studies track. Adminstration and Citizens Council should be interested in Science Tech because the curriculum addresses specific needs of students at risk. The student has the option to take the class for either science or applied ats credit. Educators that recognize the value of this instructional format will find a creative method of implementation best suited for their district. Discover a new approach to making science and technology integral components in your district.

TEACHING FUNCTIONAL TECHNICAL LITERACY

The real challenge behind teaching courses like Technology of Chemistry or Physics is connecting science theory and application. There is a relationship between pure science and the practical application we call technology. Science builds theory by exploration and discovery. Research and development converts theory into technology products that fulfill man's needs. The processes co-exist and are co-dependent. Science and technology are interdependent. An individual that can apply scientific theory to practical application is demonstrating FUNCTIONAL TECHNICAL LITERACY.

For the last several years I have been collecting articles on Technology Education. I felt someday there would be a useful purpose either for program support or general professional maintenance. The day has arrived! Three manilla folders were bulging with articles, research papers, sample literacy tests and minutes of past symposiums. My first discovery was what I feared the most; too much information! Technology has a very large informational base. A universal understanding of technical literacy could not take roots in the educational community because technology is a moving target and the understanding of literacy must move with the same velocity and direction. 'State of the art' does not exist because the 'state' is in constant motion. As one understanding takes hold, a new technology emerges broadening the scope of how one might identify a technically literate individual.

A conceptual framework for what characterizes technical literacy must be established. Dr. Jon Miller, director of the Northern Illinois University Public Opinion Laboratory, suggests that one might try to identify the 'components' that makeup a technically literate person. Technical literacy should be viewed as a continuous internal variable. (Miller, 1986). Capitalizing on the Miller research sponsored by the National Science Foundation and the work of International Technology Education Association, I adopted the postulate; Technically literate persons have an understanding of selective LEARNING DOMAINS through specific SUBJECT AREAS.

ELEMENTS OF TECHNICAL LITERACY: LEARNING DOMAINS

After a review of literature on technical literacy including sample literacy tests, (see Appendix A) I was encouraged by the patterns of information. The 'components' or indicators that are common traits of a technically literate person are classified or grouped into three familiar categories. Technical literacy is demonstrated through cognitive, affective, and effective domains of understanding.

The first component of technical literacy was identified by the repeated use of questions that asked, "how things worked." From microprocessors to motorboats, could the operating behavior of the system be explained. Functional technical literacy requires intellectual activity about the functioning of technical systems which influence our living standards. The knowledge base for technical literacy is COGNITIVE and is the first component in a description of technical literacy.

> Describe (demonstrate, illustrate or explain) the relationship of scientific principle to a practical application. The ability to describe application to principle is equally important.

The second component found common among discussions of technical literacy was the characteristic that equates invention with the effect on society. As an example, man is developing atomic power. Products of energy and medicine in the nuclear industry have been beneficial to mankind. On the other hand, the potential of doing irreversible damage to our environment is a significant threat. What is the balance between technology and society and who will make those determinations? Responsible decisions must be made that provide not only immediate benefit but protect the future. Functional technical literacy requires human judgement. A value system in a technically literate society is quite different from that in a non-technically literate society. The decision making process for a technically literate society is guided by the affective domain. AFFECTIVE knowledge is the second component in a description of a technical literacy.

> Express an informed attitude about the benefits and consequences of invention and discovery to society.

The third component found with high frequency is the suggestion that an individual possessing an ability to find solutions to problems is technically literate. Building has long been mankinds course in improving life style. Prehistoric man created tools so that he could survive. Craftsmen dominated the middle ages with high quality products. The factories of the industrial revolution were designed for mass production so all might enjoy the benefits of technology. Today, because of man's quest to find solutions and solve problems, the information age is fueled by supercomputing and the rhelms of data needed to support our search. The ability to design, construct, modify and analyze are necessary characteristics found in a technically literate individual. Man's accomplishments are a measure of his applicative knowledge. Technological leadership is a measure of applicative knowledge and the ability to put discovery to work. EFFECTIVE knowledge is the third component of functional technical literacy.

> Apply problem solving skills in finding solutions to the environmental requirements of mankind.

ELEMENTS OF TECHNICAL LITERACY: SUBJECT AREAS

Consider what is required to be a 'literate' person. You must be able to communicate, to compute, to think, etc. Technical literacy is similar in structure. Accepting Miller's conclussion on components of literacy and connecting that thought with the vision of the ITEA, a technically literate person must understand:

A) Energy Systems
B) Communication Systems
C) Manufacturing Systems, and
D) Transportation Systems

at a level that would allow an individual to function effectively in a technical society. These four study areas are to be considered as the subject areas of technical literacy.

A) Energy systems deal with the understanding of the different forms of energy and how energy is converted from one form to another.

B) Communication systems study electronic and graphic forms of communication including design, transmission, and retrieval.

C) Manufacturing systems study synthesis, materials, equipment, and processes used in construction and distribution of raw and finished products.

D) Transportation systems include the study of equipment and controls used in the delivery of materials and services.

COURSE CONTENT - A SUGGESTED LIST OF ACTIVITIES

Every teacher is talented and gifted in their own right. The subject matter and teaching strategy for Technology of Chemistry and Technology of Physics is determined collectively by the technology and science teachers. As long as the subject and activity is a practical application of science, student achievement and participation in the learning process will improve. Developing functional technical literacy will be a very challenging and very rewarding teaching experience for teacher and student alike.

Suggested Technology of Science Activities

Technology Activity	Scientific Application
Battery Testing	Specific gravity
Air Conditioning	Phase Change
Surveying	Vectors
Go-Karting (skid)	Co-efficient of Friction
Electroplating	Electrolysis
Heat Treatment	Metalurgy
Building Ohmeter Kit	Ohm's Law
Alternator Testing	Electromagnetic Induction
Emission Testing	Chemical Equilibrium
Neon Light	Wave Length
Carburetors	Venturi Principle
Solar Cells	Material Science
Tensile Pull	Metalurgy
Model Rocketry	Newton's Law

"Hands on learning" is what makes these concepts come to life. Technology can have a magical effect on learning because it's real and verifiable. Let the students have a real feel for learning. Consider the activity about air conditioning. To the technology teacher, air conditioning is: a manifold guage set, freon, a condensor, a compressor, an evaporator and an expansion valve. To the science teacher, air conditioning represents phase change, boil point, freeze point, specific heat, joule and Boyle's Law. Most importantly, to the student, air conditioning means that the science concept of phase change is understood and that a working knowledge of the science concept is readily demonstrated. Work closely with the science teacher to highlight the connection between theory and practical application. Technically literate people have a strong understanding of the practical applications of science. Use care not to try to re-teach science; teach technology.

Good luck in preparing students for careers in the 21st century through Technology Education.

A MOTTO...

TO HEAR IS TO FORGET,

TO SEE IS TO REMEMBER,

TO DO IS TO UNDERSTAND.

APPENDIX A

SAMPLE TECHNICAL LITERACY TESTS

1.) Technology Literacy Test Revised
University of Wisconsin - Stout
Dr. Lee Lee Smalley, 1985

2.) Technological Literacy Test
Ohio State University
Abdul Hameed

3.) Core Concepts for Science Technical Literacy
Potsdam College
Robert E. Snow, 1988

4.) Technological Literacy: Some Concepts and Measures
Northern Illinois University
Dr. Jon Miller, 1986

5.) Careers, Attitudes, FIT Series
SRA, Inc
Chicago, Illinois @ 1953, 1976, 1979

6.) Technology Accordance
San Jose State University
L.R. Markert, 1985

APPENDIX B

SAMPLE SCHEDULE: TECHNOLOGY OF CHEMISTRY

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
Period 1	Chem Lecture	Chem Lab	Chem Lecture	Chem Lab	Chem Lecture
Period 2	Tech of Chem	Chem Lab	Tech of Chem	Chem Lab	Tech of Chem

ENDNOTES

1.) Bourey, Al, Chemistry Teacher, A personal interview; Oak Park, Illinois (1986).

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Vince Martinek	Physics Teacher Oak Park and River Forest High School
Earl Corrigan	Dean, Career and Vocational Director Oak Park and River Forest High School
Dr. Steve Stanard	President, Stanard and Associates Chicago, Illinois

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Non-Traditional Hands-On Science Programs For High School Students at Bryn Mawr College and the University of Pennsylvania

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Stephen Gardiner, Bryn Mawr College
Robert Kuhlman, Montgomery County Community College
Charles Gallagher, Monsignor Bonner High School
Frank McCoy, Philadelphia High School for Girls

Bryn Mawr College was one of three Philadelphia-area colleges and universities selected by the William Penn Foundation in 1985 to mount science enrichment programs for the "average" range of students in the public and parochial secondary schools. The philosophy behind the initiative was twofold: (1) to increase the number of students preparing for science-based careers by motivating them to choose the most challenging science and math courses in school; and (2) to increase the knowledge of all students about science and scientists, and foster an appreciation of the role of science and technology in our society.

At Bryn Mawr, a team of faculty and graduate students representing Chemistry, Biology, Physics, Math/Computer Science, Geology, English, and Physical Education was assembled. A core of dedicated high school teachers was recruited and brought in to help plan the program. It was decided that the most effective program would be one which differed from the usual school environment. The thrust of the program would be, instead, to allow the students to experience science as it is actually practiced; to experience the affective as well as intellectual rewards that come from investigating nature; and to confront societal issues raised by scientific and technological advances.

The **WISE** Program (Windows Into Science Enrichment) began at Bryn Mawr College that summer, and Science Frontiers at Pennsylvania the next year. Each summer 120 ninth- and tenth-grade students from the Philadelphia public and parochial high schools come to the Bryn Mawr and Penn campuses. WISE students live on the Bryn Mawr campus, getting a taste of residential college life, while Penn students commute. A hands-on approach is used almost entirely; the program is built around field work and labs with virtually no "classroom" activities such as normally found in school. In addition, students directly confront social issues connected with science in a weekly "town meeting." Here, issues raised by the week's work are discussed and debated by student teams, which have prepared presentations on assigned topics.

The subject matter of WISE is organized into two themes: (1) **Environmental Science**, and (2) **Human Biology**. Some important aspects of the program are as follows:

*1. **Broad participation:*** The programs are designed specifically for a general audience: not high achievers, but the average range of students found in Philadelphia's public and parochial schools.

2. ***Minority involvement in science:*** Although not specifically designed as such, the programs serve predominantly minority students because of the composition of the school systems served. The vast majority of the students are from families whose parents did not attend college. The result is a student body that is a prime target for increasing the flow of young people into science. One of the desired outcomes is to encourage some of these students to become more interested in science and possibly to pursue scientific careers. We hope to contribute thereby to alleviating the serious under-representation of minority groups in scientific professions.

3. ***Values in science education:*** A unique aspect of our program is the attention to values. The two major themes of the program lend themselves quite naturally to questions of values and policy. In **Environmental Science** we address issues such as: land use and the conflicting demands of development vs. preservation; the intelligent siting of human uses; the wisdom of interfering with natural processes through the construction of breakwaters, jetties, highways, etc.; conflicts over limited resources; and the responsibility of mining companies for reclaiming the land. In **Human Biology** we address ethical/legal issues such as organ transplantation, drugs, AIDS, and how to curtail the abuse of harmful substances.

4. ***Hands-on teaching methods:*** The centerpiece of each unit is the lab and field work. These experiences are carefully designed to involve students in exactly the kind of studies that scientists perform, and are appropriate for the subject matter at hand. In other words, students **get their hands dirty.** The Environmental Science unit is built almost entirely around field work. Students engage in the following activities:

- At Cape Henlopen, Delaware, study the phenomenon of long-shore drift and observe how the construction of jetties and other structures changes long-shore drift patterns, causing beach erosion and silt deposition; examine sand composition to understand the relationship between water velocity and deposition of sediment.

- Observe and collect plant and animal species from a variety of environments including tidal marshes, mudflats, sand dunes, ocean shoreline, abandoned strip mines, reclaimed strip mines, polluted and relatively unpolluted streams; observe the operation of a coal reclamation process.

- Observe an underground fire and its effects on a community. Study the effects of acid water drainage from an abandoned mine and other environmental effects of mining practices in the coal-mining region of Pennsylvania.

- Contrast the health of a relatively undisturbed environment (Valley Creek in Valley Forge State Park) with that of a disturbed creek (sewage treatment outfall area of Perkiomen Creek) in terms of the distribution of organisms and other parameters.

In the Human Biology unit, students perform the following lab work:

- Use the EKG to study the effects of exercise on heart rate. Observe and study the "diving reflex," in which one's heart rate slows dramatically when the head is immersed in water. Measure the effects of temperature, breath-holding, and length of immersion on this effect.

- Use the microscope to prepare blood slides and study blood diseases.

- Measure glucose and hemoglobin levels in normal and diseased blood samples, using standard colorimetric methods.

5. Confronting social issues: Day-long "town-meeting" forums are held once a week. Social and scientific issues raised by the week's labs and field work are discussed and debated. Students are often assigned at random to either side of such a debate, thereby requiring them to become familiar with new points of view. The following are examples of Town Meeting debate topics.

A. Can human constructions such as seawalls, breakwaters, etc, subdue natural geologic processes operating on coastal areas, and bring long-term stability to coastlines?

B. Do human needs (e.g. recreational sites, energy, entertainment), override the need to maintain wilderness areas and wetlands in a natural state?

C. Should a convention center/sports complex be built in Valley Forge Park? The convention center would hold 70,000 people, cover twenty-five acres and require 75 acres of parking lot.

C. Resolved: All cigarette advertising should be banned.

D. Resolved: All applicants for employment should be tested for AIDS.

The staff has been constantly delighted by the intensity with which the students prepare for and engage in these debates. We think we have discovered a constructive outlet for the competitiveness of these youths.

6. Partnership between high school and college teachers: From the beginning, high school and college teachers worked as equal partners in the design and execution of the program, each group contributing its own special knowledge and each learning from the other.

A STUDY OF SCIENCE-TECHNOLOGY--SOCIETY EDUCATION IN TENNESSEE AS PERCEIVED BY SECONDARY SCIENCE TEACHERS

by
Jack Rhoton
East Tennessee State University

Science and technology play an integral role in today's society. A heightened concern for the integration of technology into the nation's schools has been stimulated by a series of reports in recent years (National Commission on Excellence in Education, 1983; the National Science Board Commission, 1983; and the Twentieth Century Fund Task Force on Federal Elementary and Secondary Education policy, 1983). These reports and others have, in varying degrees, influenced the debate within the science education community relative to the theme of Science, Technology, and Society Education, known as S/T/S.

The need to make S/T/S an integrating theme in science programs has been eloquently argued by the proponents of S/T/S (Harms and Yager, 1981; NSTA, 1982; Yager, 1987; Yager, 1987). Central to the debate is a focus on the needs of students to understand and make decisions on S/T/S issues that impact their lives. The S/T/S approach encompasses the idea that many of our societal issues are connected to science and technology; therefore, student retention of technology concept and information is best accomplished by grounding the teaching in socially relevant issues. "Curriculum should be organized around problem-solving skills, real-life issues and personal and community decision-making." (NSF Board Commission, 1983)

Although there has been much discussion on the rationale and goals of S/T/S in science programs, limited efforts have been focused on the attitudes and perceptions of science teachers and their role in implementing the S/T/S theme into the curriculum. However, science teachers' perception of global problems, policy issues and their implication for the science curriculum relative to S/T/S education has been discussed (Bybee and Bonnstetter, 1986, in Bybee, 1986).

A major responsibility for changing existing attitudes and practices rests with the public education system. It is science educators who will have to deal with the changing curriculum, impact of new knowledge and appropriate methodology for instruction. Implicit in consideration of such a role for public education are perceptional and attitudinal changes, not only for students, important as they are, but for teachers as well.

PURPOSE AND DESIGN OF STUDY

The purpose of this study was to investigate the nature of science/technology/society education as perceived by science teachers in the state of Tennessee. Specifically the study sought to answer the following questions:

1. What are the educational resource needs for teaching S/T/S education?

2. In what ways is the present educational system involving students in the study of S/T/S education?

3. What changes in the present educational system would teachers support in order to facilitate an increased emphasis on S/T/S education?

4. What are the major difficulties in teaching the interactions of S/T/S education?

5. What disciplines should receive primary emphasis when integrating S/T/S issues into the science curriculum?

6. At what educational levels should S/T/S programs aim?

METHODOLOGY

The study consisted of 300 secondary science teachers (grades 7-12) in the state of Tennessee. Information from the Tennessee State Department of Education listed the number of science (7-12) teachers as 3001. A stratified sample including 10 percent of this science teacher population was considered an adequate sample. The science teacher list was used to determine the percentage of science teachers in each of four stratifications. School systems were selected in an attempt to involve systems that would produce a sample that was representative of East, Middle and West Tennessee.

The primary methodology utilized was the administration of a questionnaire. The survey instrument with cover letter and self-addressed stamped envelope was mailed during February, 1987 to 300 science teachers in Tennessee. During March, 1987, all non-respondents received a follow-up letter, survey, and self-addressed envelope (Berty, 1979). Of the 300 questionnaires administered, 66.3 percent or 199 were returned. Of these 199 respondents, 10 were returned not completed or because of incorrect address. Therefore, 189 or 63 percent of the total number of questionnaires were returned as usable responses.

Study respondents were requested to respond to six sets of questions. Two types of responses were requested. Question sets one, two, and three requested the subjects to respond to a 5-point scale with "1" being the highest positive response. Question sets four, five, and six requested respondents to rank order three different sets of items.

DISCUSSION OF FINDINGS

Need of Educational Resources in Support of S/T/S

Data in Table I show the breakdown of respondents' perceptions concerning the resource needs relative to teaching S/T/S education. With regard to local or regional workshops, seminars, or institutes to strengthen mastery of technological concepts, most teachers, (88.2 percent) perceived this item as a very strong need (mean=3.67, SD=.67). The second most frequent response was a need for innovative curricular materials and approaches for S/T/S education (mean=3.53, SD=.60). The third ranked category was that of summer internships for teachers to work side-by-side with industry researchers (mean=3.34, SD=.76). Visiting scientist/engineering program to provide speakers for the science classroom and bring high-achieving science students into research laboratories to work with researchers had responses for fifth and sixth places respectively. Interestingly, all items in this set had mean scores higher than the 2.5 necessary for inclusion as a positive response as a resource need.

Present Educational System Involvement of Students in S/T/S Education

When questioned concerning the degree to which the present educational system is involving students in S/T/S education, the highest positive response was that of reading about science, technology, and society issues (mean=3.48, SD=.62). Learning science as a discipline separate from its social and technological implications (mean=3.40, SD=.86), and learning about the interactions of science, technology, and society (mean=2.91, SD=.85) were reported as positive responses by the respondents. Evaluating alternatives to S/T/S issues, acting on alternatives to S/T/S issues, and independently investigating S/T/S issues all had mean scores below 2.50 necessary for inclusion as a positive response. A summary of this data is presented in Table II.

Teacher Support of Educational System Changes to Facilitate S/T/S Education

Data presented in Table III indicate that the majority of respondents support changes in the curriculum that will facilitate S/T/S education (1-4). The highest positive response was that of changing school programs requiring studies out in the community (mean=3.48, SD=.87). Two additional mean responses tied for second place. One item dealt with focusing the curriculum of all disciplines on how technology affects people and the environment (mean=3.44, SD=.99). The other second positive response was that of teachers guiding students in discovery and investigations of S/T/S issues (mean=3.44, SD=.79). Interestingly, the lowest mean score response and the greatest percentage of negative responses (1, 2) were reported for the item related to adding a separate course on S/T/S education to the curriculum (mean=1.96, SD=.94)

TABLE I: NEED FOR EDUCATIONAL RESOURCES IN SCIENCE, TECHNOLOGY, AND SOCIETY EDUCATION

Item	Negative Response 1		2		3		4		Positive Response 5		Mean	Standard Deviation
	No.	%	No.	%	No.	%	No.	%	No.	%		
1. Local or regional workshops, seminars, or institutes to strengthen mastery of technological concepts	0	0	7	3.7	15	7.9	137	72.4	30	15.8	3.67	.67
2. Training to utilize computers and/or other innovative technologies to improve instruction	0	0	8	4.2	151	79.8	21	11.1	9	4.7	2.90	.59
3. Involvement of specialists from industry and other fields to assist teachers in developing technological concepts, processes, and instructional systems in given subjects	0	0	7	3.7	133	70.2	49	25.9	0	0.0	2.95	.53
4. Summer internships for teachers to work side-by-side with industry researchers	4	2.1	10	5.2	43	22.7	123	65.0	9	4.7	3.34	.76
5. Innovative curricular materials and approaches for S/T/S education	0	0	7	3.7	21	11.1	150	79.3	11	5.8	3.53	.60
6. Visiting scientist/engineer program to provide speakers for the science classroom	11	5.8	13	6.8	54	28.5	101	53.4	10	5.2	3.16	.91
7. Bring high-achieving science students into research to work with researchers	6	3.1	10	5.2	111	58.7	43	22.7	19	10.0	3.03	.84

TABLE II: PRESENT EDUCATIONAL SYSTEM INVOLVEMENT OF STUDENTS IN S/T/S EDUCATION

Mode of Involvement	Negative Response 1 No.	%	2 No.	%	3 No.	%	4 No.	%	Positive Response 5 No.	%	Mean	Standard Deviation
Is your present educational system involving student in:												
1. Learning science as a discipline separate from its social and technological implications.	6	3.1	10	5.2	37	19.5	115	60.8	21	11.1	3.40	.86
2. Learning about the interactions of science, technology, and society	3	1.5	30	15.8	103	54.4	37	19.5	16	8.4	2.91	.85
3. Reading about science, technology, and society issues	0	0.0	7	3.7	34	17.9	139	73.5	9	4.7	3.48	.62
4. Independently investigating science, technology, and societal issues	10	5.2	98	51.8	61	32.3	16	8.4	4	2.1	2.29	.79
5. Evaluating alternatives to science, technology and societal problems	16	8.4	128	67.7	32	16.9	13	6.8	0	0.0	2.03	.68
6. Acting on alternatives to science, technology and societal problems	13	6.8	100	52.9	62	32.8	9	4.7	5	2.6	2.23	.78

TABLE III: TEACHER SUPPORT OF EDUCATIONAL SYSTEM CHANGES TO FACILITATE S/T/S EDUCATION

Proposed System Change	Negative Response 1		2		3		4		Positive Response 5		Mean	Standard Deviation
	No.	%	No.	%	No.	%	No.	%	No.	%		
1. Focusing the curriculum of all disciplines on how technology affects people and the environment	3	1.5	21	11.1	42	22.2	77	40.7	46	24.3	3.44	.99
2. Changing school programs requiring studies out in the community	6	3.1	5	2.6	42	22.2	105	55.5	31	16.4	3.48	.87
3. Teachers guiding students in discovery and investigations of science, technology, societal related problems	0	0.0	6	3.1	67	35.4	84	44.4	32	16.9	3.44	.79
4. Teachers telling students about science, technology, and societal related problems	2	1.0	18	9.5	102	53.9	57	30.1	10	5.2	3.01	.76
5. Adding a separate course on science, technology, society to the curriculum	47	24.8	91	48.1	35	18.5	9	4.7	7	3.7	1.96	.94

Major Difficulties in Teaching the Interactions of Science, Technology, and Society Education

Data describing responses to items related to difficulties in teaching S/T/S education are presented in Table IV. Interestingly, the major difficulty, as perceived by science teachers, was the availability of curricular materials on S/T/S education (mean=1.42, SD=.81). Similarly, the item perceived as next highest difficulty was that of methods, techniques of teaching (mean=1.57, SD=.61). Preparation of teachers, structure of the curriculum, and availability of computers and/or other innovative technologies all had mean scores less than 2.5 necessary for inclusion as a major difficulty. Confinement of students in the classroom and rigidity of school schedule had mean scores greater than 2.5 and were not perceived as major constraints in teaching S/T/S education.

Disciplinary Emphasis When Integrating S/T/S Education Into the Curriculum

Referencing data presented in Table V, biology (mean=1.25, SD=.69) is the discipline science teachers felt should receive the primary emphasis when integrating S/T/S education into the curriculum. The second ranked discipline was that of general science (mean=1.85, SD=.74). Earth science and chemistry were ranked third and fourth respectively. Social studies, physics, and vocational all had mean scores greater than 2.5 indicating that respondents did not perceive these disciplines as receiving high S/T/S emphasis.

Educational Level at Which S/T/S Education Should Aim

When questioned concerning educational level at which S/T/S programs should aim, science teachers generally felt that S/T/S education should receive less attention at the elementary school level (mean=3.10, SD= 1.03). At the middle school, high school, college, and adult levels, respondents felt that S/T/S education should be integrated into the curriculum. A summary of this data is presented in Table VI.

SUMMARY AND CONCLUSION

A survey of secondary science teachers in Tennessee assessed their perceptions concerning the Science/Technology/Society (S/T/S) theme. Information generated from this study will contribute to the S/T/S debate and help clarify the nature and current practices of the S/T/S theme in the study population. The findings of the study are summarized:

1. Science teachers indicate a need for local or regional workshops, seminars and institutes to strengthen mastery of concepts relating to S/T/S education.

TABLE IV: MAJOR DIFFICULTY IN TEACHING THE INTERACTIONS OF SCIENCE, TECHNOLOGY, AND SOCIETY

	Major Difficulty 1		2		3		4		Minor Difficulty 5			Standard
Difficulty	No.	%	No.	%	No.	%	No.	%	No.	%	Mean	Deviation
1. Structure of the curriculum	43	22.7	34	17.9	76	40.2	30	15.8	6	3.1	2.37	1.0
2. Preparation of the teachers	57	30.1	81	42.8	30	15.8	21	11.1	0	0.0	1.90	.92
3. Availability of curricular mat'ls on S/T/S education	120	63.4	41	21.6	20	10.5	8	4.2	0	0.0	1.42	.81
4. Methods, techniques of teaching	71	37.5	102	53.9	15	7.9	1	.5	0	0.0	1.57	.61
5. Confinement of students in the classroom	25	13.0	39	20.6	90	47.6	16	8.46	19	10.0	2.58	1.06
6. Rigidity of school schedule	15	7.9	40	21.1	51	26.9	72	38.0	11	5.8	2.86	1.0
7. Availability of computers and/or other innovative technologies	13	6.8	107	56.6	56	29.6	13	6.8	0	0.0	2.16	.707

TABLE V: DISCIPLINARY EMPHASIS WHEN INTEGRATING S/T/S EDUCATION INTO THE CURRICULUM

Discipline	High Emphasis 1		2		3		4		Low Emphasis 5		Mean	Standard Deviation
	No.	%	No.	%	No.	%	No.	%	No.	%		
1. Biology	147	77.7	15	7.9	27	14.2	0	0.0	0	0.0	1.25	.69
2. Chemistry	13	6.8	44	23.2	129	68.2	3	1.5	0	0.0	2.42	.63
3. Physics	4	2.1	19	10.0	89	47.0	71	37.5	6	3.1	3.02	.78
4. Earth Science	31	16.4	111	58.7	42	22.2	5	2.6	0	0.0	1.93	.68
5. General Science	44	23.2	106	56.0	30	15.8	9	4.7	0	0.0	1.85	.747
6. Social Studies	7	3.7	38	20.1	61	32.2	73	38.6	10	5.2	2.95	.943
7. Vocational	6	3.1	19	10.0	86	45.5	37	19.5	41	21.6	3.17	1.02

TABLE VI: EDUCATIONAL LEVEL AT WHICH S/T/S PROGRAMS SHOULD AIM

Educational Level	High Priority 1		2		3		4		Low Priority 5		Mean	Standard Deviation
	No.	%	No.	%	No.	%	No.	%	No.	%		
1. Elementary School	5	2.64	32	16.9	70	37.0	49	25.9	33	17.4	3.10	1.03
2. Middle/Junior High	95	50.2	90	47.6	4	2.11	0	0.0	0	0.0	1.39	.53
3. High School	141	74.6	27	14.2	20	10.5	1	.52	0	0.0	1.25	.67
4. College	67	35.4	87	46.0	32	16.9	3	1.5	0	0.0	1.69	.73
5. Adult	59	31.2	64	33.8	66	34.9	0	0.0	0	0.0	1.86	.79

2. Science teachers indicate a need for innovative curricular materials for teaching S/T/S education.

3. Science teachers indicate a need for summer internship opportunities with industry researchers for both teachers and students, as well as visiting scientist/engineering programs for the science classroom.

4. Science teachers indicate the current science curriculum involves students in learning science as a discipline separate from its social and technological implications.

5. Science teachers indicate that the current science curriculum involves students in reading about the S/T/S theme rather than independently investigating S/T/S issues.

6. Science teachers indicate a willingness to support a variety of educational system changes to facilitate S/T/S education except that of adding a separate course on S/T/S to the curriculum.

7. Science teachers indicate the major constraints in teaching the S/T/S theme include a lack of S/T/S curricular materials, teaching methodology, preparation of teachers, structure of curriculum, and availability of computers and other innovative technologies.

8. Science teachers ranked biology, general science, earth science and chemistry as important disciplines areas when integrating the S/T/S theme into the curriculum.

9. Science teachers indicate S/T/S programs should aim at middle/junior high through adult education with a lower priority at the elementary level.

Perceptions of science teachers in Tennessee do not support the view that the S/T/S theme has become firmly entrenched in the science curriculum. However, there is a willingness on the part of teachers to support educational changes to facilitate the S/T/S theme. The implications for scientists, science educators, school administrators, curriculum developers, and teacher education are obvious. Much attention must be directed at going beyond the structure of the scientific discipline to the interphasing of the science-based societal issues as a basis for integrating the S/T/S theme into the curriculum.

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ADDRESSING GLOBAL ENVIRONMENTAL ISSUES IN SCIENCE-TECHNOLOGY-SOCIETY COURSES

Teny Topalian

It is interesting to note that science education has been cyclic. There was a time when science was only for the elite, more mathematics and science for the college bound student.

Things changed in the early seventies. There began a concern about the decline in the competency of students in science. In fact, in the September/October 1988 issue of American Scientist, Hively reports that "The middle-aged adults of the year 2010 are already in high school. Unless they are locked up until they learn more science, about 95% will be scientifically illiterate."

According to Jon Miller (1988), Director of the Public Opinion Laboratory at Northern Illinois University, the level of scientific literacy is 5%. One in 20. He continues to define the "scientifically literate" as one who understands the scientific method and vocabulary well enough to follow public debates about issues involving science and technology. Miller believes that scientific literacy also means appreciating the social impacts of science.

This rise of concern about what the nature of science education should be has initiated a movement of curriculum reform. No longer are just the facts of science important, but so are its effects on society.

Science can be defined as a systematic method of gaining philosophical knowledge about the world, the universe, and ourselves. This systematic method is characterized by various processes, some of which include: observation, inference, communication, predicting, hypothesizing, and controlling variables.

Science knowledge and science processes are important, but science values must also be included. Some values of science or scientific attitudes are:

1. longing to know and understand
2. questioning of all things
3. search for data and their meaning
4. demand for verification

5. respect for logic
6. consideration of premises
7. consideration of consequences
8. tolerance of different viewpoints
9. the desire for creativity
10. curiosity

The two major defects in the teaching of science today are:

1. Its failure to lead to any adequate philosophical model of the world around us and within us.
2. The failure to incorporate its facts with values, with the consequence that it appears to be ethically and morally detached.

Mendelsohn (1981) blames science education for teaching "Naive materialism, primitive positivism and complacent technocracy." This is because science education is largely committed to "conventional valid science." It is the information you need to build bridges and nuclear plants or to cure diseases. It is the science behind the technological society. Conventional science attempts to be value free. Science education is carried out as if historical, philosophical, political, sociological and economic aspects of life are unworthy of attention.

Students must understand the nature of science and the scientific method, the philosophy and history of science gives them a better comprehension of the scientific concepts; the politics, economics, sociology and ethics of science are crucial elements in any Science-Technology-Society program.

There needs to be a change in the mind-set of teachers of science at all levels. In the same token, there is also a need for greater consciousness of the responsibility of the scientist to the society that she/he inevitably helps to create. Science has its own set of values, like a constitution that guides scientists.

There are differences in values espoused by the scientific enterprise and those actually practised by the individual scientists. For instance, scientists publicly revere objectivity but rely on subjective hunches in the privacy of their laboratories.

Mendelsohn (1981) concludes that some of the basic scientific values are inadequate. In their place he suggests:

1. Modesty - to replace the arrogance of contemporary science.

2. Accessibility - science must be accessible to the general public in terms of understanding the enterprise, and participating in important decisions.

3. Consideration of non-violent, non-coercive and non-manipulative research - an oath similar to the Hippocratic oath of physicians should transform the relationship between science and society.

4. Harmony with nature - concern with long-term effects of tampering with nature, and asking, will the activities we undertake benefit the quality of human life?

In the teaching of science, if we encourage teachers to promote active vs passive, analytic vs descriptive, experimental vs informational methodologies, then we are encouraging science education for society. Teachers must teach their students that science is not just a collection of facts, it is a creative process, a way of thinking. The teaching of science should incorporate preparing students to become responsible citizens. By this I mean a S-T-S course can enhance the individual's ability to understand her or his condition in the community, and the world. It provides the individual with a realistic perspective on local, national and world issues, problems and prospects; for science has for some time had the largest influence on our lives. Science education offers the most direct way for students to learn about the products, processes and influences of science and technology. Science teaching should reflect the greater recognition of global problems in the broader theme of the relationship between science, technology and society.

Teachers need to be exposed to a variety of activities that will permit them to instruct students in a way that will instill such goals. It is important to note that a S-T-S program need not be taught separately, it can be infused into existing biological, physical or earth sciences.

The most promising way to raise ethical issues concerning applied science and technology is to develop courses dealing with specific public issues such as energy policy, environmental policy, mineral policy, food and agricultural policy or nuclear weapons policy. By focusing on particular past, present and future policy decisions, the scientific, economic, political and ethical dimensions can be brought out. In case studies of policy analysis the relevance of justice, participation, sustainability and other values will become evident. There will be opportunity for systematic ethical reasoning in real-life situations involving current legislation, resource planning and our choices as citizens, consumers and scientists. Teachers can discuss "real world" environmental problems. Topics can range from population growth, world hunger and food resources, war technology, genetic engineering, air and water quality, marine resources, deforestation, land use, energy shortages, hazardous wastes, human health and disease, extinction of species and nuclear reactors.

Environmental education is not limited to the study of natural environments, it necessarily includes human or cultural environments. Many S-T-S programs have topics related to environmental quality. Since a S-T-S approach to science education programs has not yet totally materialized, we can have them addressing global environmental issues, since a lot of the goals are similar. No area of education is more bound up with environmental issues than science and technology. Many of the world's problems are the results of science and technology misapplied.

Science explains what is, technology creates what never existed before. A concern for environmental improvement can be articulated through a science and technology education which promotes sustainable development. Science and technology have unfortunately, often been used to foster development which leads to the exhaustion of natural resources, the deterioration of the environment and the extinction of species.

It is for these reasons that I have chosen the following examples. They are actual cases summarized from the most recent scientific issues taken from New Scientist. Each case is followed by a series of questions for debate. Most are environmental, interdisciplinary and global in nature. Many similar cases may exist in different parts of the world. Of course there are many other environmental issues that should be addressed. The following are examples of what can be done.

THE TROPICAL RAINFORESTS OF BELIZE

Belize is one of the most peaceful and stable countries in Central America. It has the second most extensive coral barrier reef system in the world after Australia. Scientists have recorded more than 700 species of trees and 4000 species of flowering plants on the island. The countryside is also rich in cultural ruins such as that of the 2500 year old Mayan ruins.

Presently, it is torn between economic development and trying to preserve some of the finest tropical habitats in the world. A recent incident demonstrates this. When orange groves in Florida and California were badly damaged by frost, Coca Cola decided that Belize looked like a perfect alternative. Friends of the Earth in Europe and the United States objected to destroying virgin rainfall forests. Violent demonstrations outside the U.S. Embassy were held in Bonn. Coca Cola dropped its Belize project. Reactions to Coca Cola's pullout were bitter. The government was outraged that foreign pressure had forced the company out. Minister Lindo of Belize said: "I feel that people like Friends of the Earth should mind their own business." The government felt that this incident had jeopordised the attractions of the country to other foreign investors.

1. What do you feel is more important for the people of Belize? Economic development or preservation of its tropical rain forests? Why?

2. Why should we be concerned about tropical rainforests in the U.S.?

3. Do you believe in conservation or preservation of natural resources? Discuss.

FUEL SHORTAGES IN BRAZIL

Brazil has achieved a modern miracle. By the mid-1970's Brazil had evolved a 4-part strategy on energy: 1) continuation of the hydroelectricity program; 2) development of nuclear power; 3) intensive exploration for domestic oil; 4) replacement of petrol with alcohol made from home-grown sugar cane.

For the most part, this energy policy was and is a success. The nuclear program has been a success, but it was the alcohol program and the domestic oil industry that rescued Brazil from the economic mire. Supporters of the alcohol program say that its success is self-evident: it saves Brazil foreign exchange on oil imports, provides more security in supplies of energy, creates rural jobs and gives stability to a beleaguered sugar industry. It is also the largest program in the world. Critics say, on the other hand: it is elitist, benefits a small number of rich people, it is costly and causes considerable environmental pollution.

Plantation owners have displaced many small farmers. American farming methods and technologies were imported wholesale, with no regard for Brazil's poorer farmers.

At first sight, it may seem more moral to grow food than to use farmland to grow fuel. But some say the country would otherwise have needed a large quantity of cash crops to pay for imported oil. Several countries have learned from Brazil that it can be more economical to produce a local supply of fuel alcohol than it is to produce sugar for export.

In 1982 UNEP named Brazil as the world's worst polluter. Distilleries produced large amounts of liquid waste, or stillage that was dumped into rivers, lakes and waterways.

Also, a quarter of Brazil's population (>30 million people) are undernourished because they are too poor. The area devoted to sugar cane has risen from 1.5 million hectares - 1972 to 3.8 million hectares - 1988.

1. What is your opinion about:
    (a) hydroelectricity as a source of energy?
    (b) oil?
    (c) nuclear power?
    (d) alcohol from sugar cane?
    What are the advantages and disadvantages of each source of energy?
2. Is there such a thing as 'clean energy'? Explain and give an example.
3. Are you for or against supporting the alcohol program? Why?
4. Should a country like Brazil use agricultural land for food or fuel? Give reasons.

IS IT REALLY THE END OF WHALING?

In 1982 the International Whaling Commission voted for a moratorium on all commercial whaling. But it was a temporary measure, to be reviewed no later than 1990. It was intended to give scientists time to remove doubts about figures of sustainable yields.

Some countries like Japan and USSR continue whaling. Other countries are against whaling of any kind. They believe that killing whales is always wrong; regardless of how many whales there may be.

One can argue that this attitude is ecological nonsense. Ecological systems keep going by one animal eating another, and people can be considered as another predator. On the other hand, one can argue we have a higher responsibility and should not kill any animal.

1. Does conservation mean ensuring that catches are kept within reasonable bounds and that depleted stocks are allowed to recover? or
   Does it mean a sensible balance between the current use of a resource, and conserving it for possible use in the future?

2. Is killing whales wrong in principle? Why?

3. If most people in England or Australia think it is wrong, to what extent are they entitled to impose their view on the Japanese, Russians or Icelanders?

*This is an issue not just confined to whales, but also to the killing of seals in Newfoundland and kangaroos in Australia.

POLLUTION IN SAN FRANCISCO BAY

San Francisco Bay can provide us with an apparent harmony between nature and city. The estuary is the largest on the Pacific Coast of the U.S.

Despite many campaigns to clean and restore the estuary, there are still problems. There are patches of heavily contaminated sediments, and fish and wildfowl have high concentrations or toxic contaminants in their body. The fisheries that made Fisherman's Wharf famous, have declined, and development threatens the last remnants of San Francisco Bay's marshes.

1. How do you feel about toxicants entering a water ecosystem, whether an estuary, a river, or an ocean?

2. What is the importance of preserving marshes? Why not develop on them?

3. Why should we be concerned about fish and wildfowl?

4. Is dilution a solution to water pollution? Why or why not?

5. Should we be concerned about the quality of water in other parts of the world? Why or why not?

6. What should industry do with its wastes?

7. Do we have any responsibilities towards future generations? Why or why not?

GENETIC ENGINEERING

Earlier last year, on April 1, 1988, a public notice appeared in the local newspapers in Oxford, England. It was an issue about biotechnology - the release into the environment of organisms that scientists have genetically engineered in the laboratory. It will be the release of a virus that infects caterpillars of certain moths, such as the pine beauty moth, which causes severe damage to pine forests. Some people feared that this would disturb the delicate ecological balance and had "moral or philosophical" objections to the release of novel strains of organisms into the environment. Yet scientists felt that the dangers were overstated.

1. How do you feel about genetic engineering?

2. Do you think it is 'morally' wrong to release new strains of organisms into the environment? Why or why not?

3. What do you think about using such techniques with human beings?

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THE NEW YORK SCIENCE, TECHNOLOGY AND SOCIETY EDUCATION PROJECT

AN STS MODEL FOR NEW YORK STATE

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APPENDICES

Appendices are not included in this report. Additional information and project materials may be obtained by contacting Jack Valentine, c/o New York Power Pool, 3890 Carman Road, Schenectady, NY 12303. Telephone: (518) 381-2220.

Introduction

Gas lines, reduced long-distance auto travel, energy conservation and energy independence in the U.S. were hotly debated topics during our two oil shortages of 1973-74 and 1978-79. These energy "crises" captured the attention of the public and politicians, and produced a relatively short-lived spurt of national interest in energy education. This interest stimulated funding for a variety of energy education curriculum development efforts.

History of Project Development Efforts

The New York Science, Technology and Society Education Project traces its roots back ten years, to this time of public concern. In 1977 the New York State Education Bureau of Science Education, in cooperation with the State University at Albany's Atmospheric Sciences Research Center proposed a comprehensive energy education program to the U.S. Department of Energy. The proposal for funding included developing and disseminating curricular materials on four important energy topics: renewable energy sources, fossil fuels, energy conservation and nuclear energy

The Department of Energy agreed to fund the development of the renewable energy units. Thus, the Solar Energy Education Project was born. Material in the current Project Student Activity booklet on Renewable Energy was written for the Solar Energy Education Project. In 1979-80, separate proposals to the New York State Energy Office and the National Science Foundation were successful in funding the development of another of the four topics initially identified: energy conservation.

In 1981, the national government's interest in funding energy education efforts began a slow, steady decline. For example, the U.S. Department of Energy ended its support of in-service energy workshops for teachers in 1982. Around that same time the National Science Foundation phased out practically all funding for science education, and eliminated the Science Education Directorate within the Foundation.[1]

Thus, in the early 1980s, the job of producing a comprehensive energy education program for New York was not yet complete. And with the virtual disappearance of Federal support, some feared the program faced an insurmountable road block.

In 1982, Edward Lalor, Director of the Division for Curriculum Services of the State Education Department, and Volker Mohnen, Director of the State University at Albany's Atmospheric Sciences Research Center, approached the New York Power Pool for help. This central coordinating agency for New York State's electric power systems[2] agreed to provide funding to finish the job, through the contributions of its members. With this funding, the New York Energy Education Project began a four year curriculum development effort in the winter of 1983.

Since 1982, over one million dollars of funding from electric and natural gas utilities in New York State has been committed to the Project. Table I provides funding details, and activities.

TABLE I. PROJECT FUNDING, 1982-PRESENT

Time Period	Activities	Amount[3]
1982-1986	Original Project; Developed Fossil Fuels & Nuclear Energy Booklets; Elementary Units; Tape-Filmstrip; plus dissemination of materials through teacher workshops.	$890,000
1986-1987	(Dissemination of materials)	87,000
1987-1988	(through teacher workshops)	127,000
1988-1989	Transition to NYS^{2}TEP; Develop prototype STS unit; secure additional funding.	179,000

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[1] Funding for science education activities at the National Science Foundation was re-established in 1986.

[2] Central Hudson Gas & Electric Corporation, Consolidated Edison Company of New York, Inc., Long Island Lighting Company, New York Power Authority, New York State Electric & Gas Corporation, Niagara Mohawk Power Corporation, Orange and Rockland Utilities, Inc. and Rochester Gas and Electric Corporation

[3] Funding from 1982-87 was provided by the eight member electric systems in the New York Power Pool. Since 1987, two natural gas utilities, National Fuel Gas Distribution Corporation and Columbia Gas of New York, Inc., have also provided funding.

Project Goals

The New York Energy Education Project identified a series of goals to accomplish during its four year curricula development effort:

To develop relevant curriculum material that is scientifically accurate and can be successfully taught.

To develop a state-wide network of knowledgeable energy educators (resource agents).

To encourage a large number of teachers to incorporate energy education into the classroom.

To help children learn accurate information about energy sources, how energy works, and how energy can be conserved. Children should also learn about issues in planning the energy future.

To affect the behavior of children by causing them to communicate about energy to parents and other adults and to alter behavior and attitudes related to energy issues.

Materials Development

Because energy issues have controversial aspects, all sponsors of the Project were concerned that project materials and workshops reflect a nonpartisan, objective view of energy issues. To ensure this objectivity, an Advisory Committee[4] of educators, scientists and industry representatives met regularly to advise Project staff. (Figure I indicates the organizational relationships in the Project.) In addition, sixteen organizations[5] agreed to review draft materials and supply comments. This review group, which ranged from Brookhaven National Laboratory and the Scientists Institute for Public Information to the Center for

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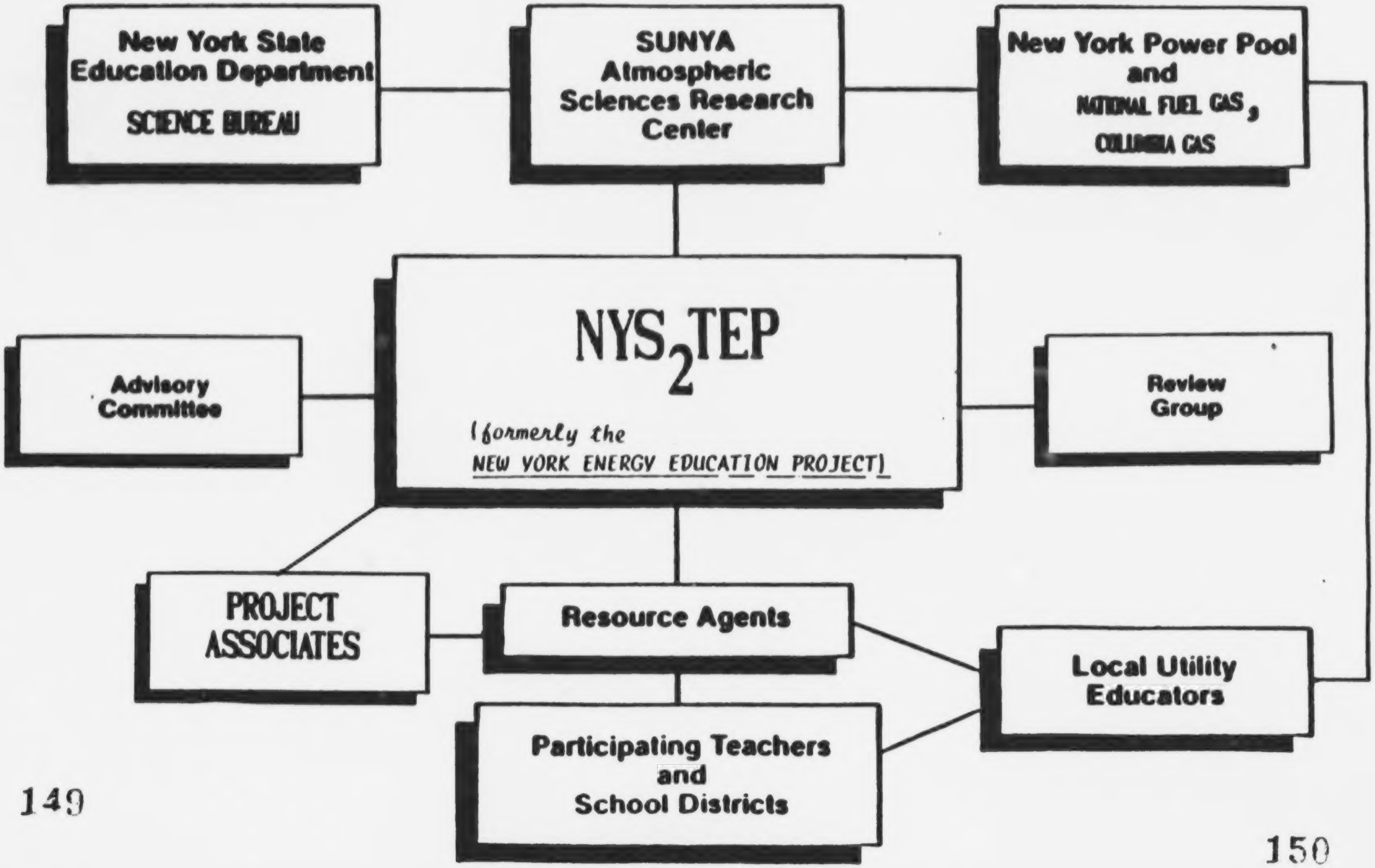
[4] Allan S. Brower, Eugene M. Ezersky, Daniel G. Plummer, Gabrielle I. Edwards, Anthony J. Gallo, and Morris H. Shamos

[5] Brookhaven National Laboratory; Business Council of New York State; Center for Environmental Information; Environmental Education Advisory Council; League of Women Voters; National Association for the Advancement of Colored People; New York Farm Bureau; New York State Congress of Parents and Teachers; New York State Department of Environmental Conservation; New York State Department of Environmental Conservation; New York State Energy Office; New York State Industrial Arts Association; New York State Society of Professional Engineers; New York State United Teachers; Science Council of New York City; Science Teachers Association of New York State; Scientists' Institute for Public Information.

NYS$_2$TEP

A COOPERATIVE PROGRAM OF INDUSTRY AND EDUCATION



New York State Education Department
SCIENCE BUREAU

SUNYA
Atmospheric Sciences Research Center

New York Power Pool and
NATIONAL FUEL GAS,
COLUMBIA GAS

Advisory Committee

NYS$_2$TEP
(formerly the
NEW YORK ENERGY EDUCATION PROJECT)

Review Group

PROJECT ASSOCIATES

Resource Agents

Local Utility Educators

Participating Teachers and School Districts

Figure I.

Environmental Information and the Business Council of New York State, provided much valuable feedback during materials development.

As draft materials were developed, they were field-tested in selected schools, and field test teacher comments were used extensively in revision.

The close working relationship between Project staff and the State Education Department's curriculum specialists allowed the Project to integrate the material it developed into the state syllabi for various courses of study. For example, three of the ten middle-junior high State science syllabi "blocks" (units) are on energy. Project materials and activities are prominent in several of them. The new State Elementary Science Syllabus also features Project material. This integration increased the receptivity of local teachers to Project workshops and materials.

Project Materials

The primary target for the New York Energy Education Project was students in junior high and middle schools, generally grades 6-9. To provide the maximum in flexibility and usefulness all materials were designed for:

- infusion--individual activities can be selected and used wherever they are useful, in science, social studies, technology, home and career skills, etc.
- ease of use--materials are readily available in typical schools or inexpensive to obtain. Teacher background is provided in each activity, so no additional information is necessary before doing the activity.

The Junior High Package

The junior high materials are included in Appendix I. They include four activity booklets containing student directions, worksheets and teacher background information. Each includes a glossary of terms and an activity matrix which relates individual activities to specific grade levels and subject areas. Each booklet is briefly discussed below.

RENEWABLE ENERGY

Seven activities include constructing a simple solar collector using several cans and different insulations, building a paper model of a passive solar home, and determining if wind energy is feasible at your home or school by collecting data on site. Also included is an activity to construct a working air-type solar collector panel, and another activity which encourages discussion of the lifestyle changes that accompany use of alternative energy sources.

ENERGY CONSERVATION

Six activities which focus mainly on home energy use. Students conduct a survey of their current household use of appliances compared with their parents and grandparents when they were the same age, keep a personal energy use journal, test insulation materials for effectiveness, and perform their own home energy audit. Also included is an activity on investigating efficiency in a gasoline engine.

FOSSIL FUELS

Nine activities which highlight our societal dependence on fossil fuels. Students learn about renewable and non-renewable energy sources, explore energy conversions and efficiency, and calculate how long fossil fuel reserves will last (assuming constant use). An activity on coal strip-mining, the greenhouse effect and testing for acid rain is included, together with another activity which asks students to interpret energy cartoons, charts and maps.

NUCLEAR ENERGY

Seven activities which teach about radioactivity, and how nuclear energy can be harnessed to produce electrical energy. Several games and role-playing activities are included. For example, "atomic bowling" demonstrates some atomic structure concepts. Because of the technical nature of this booklet, some activities require other activities in the booklet to be completed as prerequisites. Thus, the infusion model used by the Project could not be employed here completely.

In addition to these four activity booklets, other components of the junior high package are also included in Appendix I. They are:

- Twenty-one student readings on various energy sources, with comprehension questions. Each is typically one to two pages in length, and is easily reproducible.
- Sixty-five transparency/ditto masters, featuring graphs, diagrams and maps illustrating energy information. Each contains teacher background information. Useful for teacher lecture or for student handouts. The student readings and transparency/ditto masters are included inside a cardboard container labeled "Energy Options".
- Energy Futures guide to using the Project materials. Provides an index of all student activity booklets, readings, transparency/ditto masters, plus suggested energy units of varying lengths. A risk/benefit activity is also included, with teacher background information. Features an extensive annotated

bibliography of energy education resources, including teaching materials and software.

- Energy Options: Choices That Will Shape Your Future are two filmstrips with accompanying cassette tapes. The first filmstrip outlines the range of energy options, while the second suggests questions to answer when making choices about energy options.

The four student activity booklets, and the transparency/ditto masters were **revised** in 1987-88, to include updated energy statistics, and other current information. In the revision process, we also correlated the four activity booklets with the core concepts and understandings for the new (Ninth Grade) New York Regents Competency Test in Science (from the Information Bulletin: Regents Competency Testing Program in Science). The booklets are now correlated with the content outline components of the ten modules from the Introduction to Technology syllabus, for grade 7-8 students in New York State, also. These correlations provide New York State teachers with a convenient way to locate activities in Project materials which help to teach or reinforce objectives in various State course syllabi.

The Elementary Package

During the Project, the originally-planned elementary package of materials on electrical safety evolved into a series of elementary science activities emphasizing electricity. The two hallmarks of the junior high package (infusion, and ease of use) were also used to prepare Energy and Safety: Science Activities for Elementary Students.

In addition, the elementary materials emphasized a hands-on, inquiry-based approach to science. Each activity posed a question for students to answer. Parental cooperation was encouraged by including a note to parents suggesting ways they could help reinforce the ideas their children were learning currently. Each activity also included an appropriate energy safety hint. The activities for all three levels of Energy and Safety were correlated to the appropriate levels of the State Elementary Science Syllabus. Activities included at each level are discussed below. For a copy of Energy and Safety, see Appendix II.

LEVEL ONE (Grades K-2)

Twelve questions for students introducing energy and what it can do. Includes popping corn to learn that energy makes things happen, and making and coloring a mobile of energy uses and sources. Student can make a "draft detector", to use at home to see how they may save energy.

LEVEL TWO (Grades 3-4)

Thirteen questions mainly on electricity and other forms of energy. Students learn about making a path for electricity using batteries, wire, a light, and several electrical conductors and non-conductors. Also included is making a terrarium, and a contest to see who can make their ice cube last longest (using various insulations, etc.).

LEVEL THREE (Grades 5-6)

Thirteen questions focusing on using energy. Students make a waterwheel, learn how to recycle paper, and trace the energy changes in a car. Also included is an activity on learning about acids, the concept of pH, and testing various materials for acidity.

Teacher Workshops: The Key to Utilization

Project materials, no matter how well-produced or field tested, are no more than dust-catchers on a shelf unless they are used. The New York Energy Education Project used a flexible in-service delivery system to get the message out to classroom teachers. (Figure I, located earlier in this document, provides the organizational framework for this delivery system.)

A cadre of forty, mostly full-time classroom teachers was recruited in 1983 to serve as Resource Agents for the Project. These agents were trained in using Project materials in a series of Summer Institutes each year from 1983 to 1986, and also in summer, 1988. Each agent organized local workshops to disseminate the elementary and junior high materials. They encouraged other energy education efforts, such as fairs, contests, assembly programs, and also suggested energy resources to local teachers, upon request.

To aid in the dissemination efforts, four Project Associates with extensive background in energy education and experience as workshop presentors were selected to help in presenting local workshops, working with the Resource Agents, other Project Staff and the local utility education representatives. The Project Associates were geographically placed so as to be readily available to Resource Agents in their area.

(Biographical data on both Project Associates and Resource Agents are provided in the New York Energy Education Project, 1982-86 Final Report[6] in Appendix III.)

The Workshops ranged from one-hour faculty meetings to all day programs, with the presentation tailored to the audience. Some workshops were for single districts or schools, others included teachers from many districts meeting at a local BOCES (Board of Cooperative Educational Services) or an area Teacher Center.

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[6] New York Energy Education Project, 1982-86 Final Report, pp. 20-33.

In each workshop, the local Resource Agent, often together with either Project Staff or a Project Associate, would present a motivational slide show or talk. The State Education mandates related to energy education would then be discussed, with project materials highlighted. Some hands-on activities would be included, followed by a presentation by the local utility education representative on resources and help available from industry. Each workshop would wrap-up with an evaluation by participants.

Teachers who attended a Project workshop received a complete set of Project materials (either elementary or junior high, depending on the workshop and audience) at no charge. Also, one Energy Options filmstrip would be sent directly to the librarian or media specialist at the school of each junior high teacher attending. (This was done to encourage use of these audio-visual aides, beyond the classroom of the teacher attending the workshop.)

Workshop teachers were encouraged to share the materials with colleagues at their schools. The materials could be freely copied by the teachers. However, Project policy prohibited supplying extra sets of materials upon request, without attending a Project workshop. The Project does fill out-of-State requests for materials, at the cost of publication, because workshops are only available within New York State.

Beyond the effective dissemination of materials directly to teachers who could use them in their own classrooms, our Workshop delivery mode had another important advantage. It encouraged cooperation between the local Resource Agent and the utility education representative. Both were involved in the planning and conducting of Project workshops. The teachers and schools participating in these workshops were then often eager to learn about, and utilize other available educational services from their local electric and gas utilities.

Over the four year lifetime of the original Project plus dissemination efforts through 1988, over 500 workshops have been conducted, reaching over 8,000 teachers throughout the State.

In fact, when viewed in terms of the total school districts in the State, the Project reached 80.4% of the districts during 1983-86 (i.e. by one or more district teachers attending a Project Workshop). Almost 65% of the middle and junior high schools in the State had at least one teacher attend a Project Workshop in this same time period. Table II summarizes the Project impacts in terms of types of teachers who attended the Workshops.[7]

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[7] Ibid., p. 40.

TABLE II. TEACHERS ATTENDING PROJECT WORKSHOPS, 1983-86

Teachers	Total in NYS, 85-86	Reached by NYEEP, 83-86	Percent Reached
K-6 Common Branch	42,592	2,850	6.7%
Junior High Science	2,823	1,197	42.4%
Technology, 7-12	3,278	448	13.7%

Evaluation of the workshops' effectiveness has been reported.[8] Evaluations completed by workshop participants indicated the vast majority (99%) rated the program useful or very useful.

It also appears that the Project material has successfully reached students in the schools. A random set of workshops were selected, and questionnaires distributed to participants. In these workshops, more than 90% of those responding indicated plans to use workshop materials. About six to ten weeks after the workshops, phone interviews were arranged with teachers who had attended. Approximately eighty per cent of those interviewed had either already used Project material or had immediate plans to do so.

Awards

The Energy Education Project received both State and Federal recognition for the quality of its curricular development and dissemination efforts. In 1984, the Project received the Governor's Award For Energy Innovation from the New York State Energy Office. Also in 1984, we were recognized by the United States Department of Energy, receiving their Award For Energy Innovation. The National Association of Industry-Education Cooperation honored the Project with its Educational Sponsorship Award in 1988.

The Next Step: NYS$_2$TEP

The New York Energy Education Project has now officially been renamed the New York Science, Technology and Society Education Project. The Project is now planning on developing curriculum materials which help teachers provide instruction on science and technology in a social context (STS). We believe the Project is well-positioned to develop these STS curricular materials. Our existing energy education materials already include some STS concepts and concerns. For example, the student activity booklet on Nuclear Energy deals with a number of global social issues (nuclear waste management, breeder reactors, construction costs, safety and terrorism). Our new materials will be developed within an STS framework to highlight such features. Appendix V contains the current Project brochure, which features our new STS emphasis.

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[8] Clark, Richard M., New York Energy Education Project Final Evaluation Report, August 22, 1986. Department of Educational Psychology and Statistics, State University at Albany. This document is included as Appendix IV. Project evaluation is also reported in the 1982-86 Final Report, pp. 43-47, which (as noted previously, is included here as Appendix III.

The goals for NYS$_2$TEP include:

Maintaining the momentum and accomplishments of past educational programs.

Obtaining supplemental funding to permit STS curricular development.

Continuing and enhancing the energy industry, State University at Albany, and State Education Department partnership.

Facilitating implementation of the State Education Department's concept that science and technology be taught and learned in a relevant, societal context rather than in isolation.

Assuming adequate funding, the Project will focus future development to help students understand the important role that technology plays in their lives and the decisions involved in the use of technology.

The Project's existing network of resource agents and associates will recognize and provide guidance to help teachers circumvent the difficulties encountered as they modify content and change teaching styles to accommodate STS material. In fact, our 1988 Summer Institute for NYS$_2$TEP Resource Agents focused on the necessary planning to restructure our own in-service delivery system for STS curricular materials, as they become available. We also discussed the potential problem areas of middle school teacher knowledge, motivation, and skill levels, which must be addressed if STS curricula is to be successfully implemented statewide.

Conclusion

The development and dissemination of the energy education materials has been successful. A network of resource agents, who regularly work and cooperate with their local utility education coordinators now exists in New York State. Through the funding support and interest of electric and gas utilities who service New York residents, a well-received and relevant package of energy education materials are now being used in State classrooms. As one sponsor remarked, "All the elements for a disaster--university, government, industry, nuclear advocates, solar advocates, conservatives, liberals--all these elements and more came together to aid the education of students in the energy area--and it worked."[9]

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[9] Ronald Stewart, Associate Director, Atmospheric Sciences Research Center, State University of New York at Albany

A member of the advisory panel summed it up well: "I found the New York Energy Education Project particularly gratifying because it tackled this difficult subject without compromising scientific principles and without yielding to special interest groups. The result is a solid framework from which any competent teacher can fashion truly effective study plans for his or her classes."[10]

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More information on obtaining existing Project materials or future plans can be obtained by writing Dr. William Peruzzi, New York Science, Technology and Society Education Project, State Education Department, Room 232-M EB, Albany, NY 12234.

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[10] Morris H. Shamos, Past President, New York Academy of Science and the National Science Teachers Association

THE CRISIS IN BIOLOGY EDUCATION: HISTORICAL PERSPECTIVES

George E. Webb

Within the past few years, science education in the United States has been exposed as largely inadequate to the task of establishing scientific literacy. Despite the acknowledgment that a lack of such literacy isolates individuals from the reality of the modern world, the American education system appears unable to teach science in a meaningful fashion. The failure of science instruction is particularly disturbing in secondary biology education, as these courses frequently represent the only science exposure for high school students. Although this situation is of crucial importance to America of the late twentieth century, an examination of the historical dimensions of the problem provides a much-needed perspective on our current difficulties.(1)

If American colleges and universities were slowly coming to terms with evolution in the last decades of the nineteenth century, the case proved quite different in the nation's public schools. Evolution remained absent from the high school curriculum throughout the late 1800s. One of the reasons for this was emphasized in a *Popular Science Monthly* editorial in early 1891. The choice of subjects to teach in the public schools was not based on what was best for education, "but merely [on] what courses of study will be free from objection on the part of this, that, or the other section of the electorate." Even David Starr Jordan, president of Indiana University and noted as an evolutionist, addressed the Indiana State Teachers' Association in late 1889 on the topic of biology instruction without mentioning evolution.(2)

The status of evolution in public education soon began to change. Evolutionary ideas were clearly visible in the botany and zoology texts used early in the century as well as in the newer biology texts which followed curricular reforms during the second decade of the twentieth century.(3) *Botany for High School*, for example, written by Cornell professor George Atkinson in 1912, forcefully stated that evolution "has been accepted because it appeals to the mind of man as being more reasonable that species should be created according to natural laws rather than by an arbitrary and special creation." Three years later, a zoology text co-authored by Vernon L. Kellogg and Rennie W. Doane included the statement, "Although there is much discussion of the causes of evolution there is practically none any longer of evolution itself. Organic evolution is a fact, demonstrated and accepted."(4)

The growing presence of evolutionary concepts in public education proved increasingly troublesome to religious conservatives. Because Fundamentalists were more concerned with the moral than the social aims of education, their concern with evolution in the public schools took on an added dimension. Rejecting the growing secularization of American education, Fundamentalists continued to view the public schools as agencies for the dissemination of traditional morality based on orthodox theology. Exposing students to concepts of biological evolution challenged these traditional views and provoked an expected reaction on the part of concerned observers. In 1914, for example, the Galveston (Texas) Ministerial Association appointed a committee to confer with the state superintendent of public instruction concerning evolutionary statements in a geography text approved for use in the public schools. After a discussion of the matter, the superintendent convinced the publisher of the text to rewrite the offending paragraph to satisfy Fundamentalist objections.(5)

Concern for the path education seemed to be taking in the United States led evangelical authors to produce several volumes indicting the educational establishment. William Bell Riley's The Menace of Modernism (1917) included many attacks on the intellectuals and educators who seemed to be challenging the orthodox world view embraced by Fundamentalists. University officials, liberal pastors and teachers at various levels proved their loyalty to modernism "by their scoffs at Scripture, their rejection of Jesus, their insistence on Darwinism, their exaltation of Man!"(6) More specifically concerned with the impact of evolutionary teaching in the schools was the 1923 diatribe Hell and the High Schools: Christ or Evolution, Which?, written by Baptist evangelist Thomas T. Martin. Arguing forcefully that high school students in America were doomed to Hell because of their acceptance of evolution, Martin placed the blame for this state of affairs jointly on the intellectuals who had changed American education and the parents who had allowed this to happen. He accused the parents of America of "cowering before the sneers of a lot of high brows supported by your taxes," and refusing to challenge the teaching of evolution in the public schools. Martin urged his readers to revolt against the situation in the high schools as the best method to stem the tide of infidelity which seemed to be swamping orthodox America.(7)

The most obvious result of the concern over the teaching of evolution was the campaign to pass laws prohibiting such teaching. During the 1920s, antievolutionists introduced legislation in more than three dozen states, with Tennessee, Arkansas, Mississippi and Oklahoma enacting prohibitions on the teaching of Darwinism. Tennessee's antievolution law brought about the famous Scopes Trial in 1925, in which a high school science teacher became the only individual ever convicted of violating such a statute. Characterized more by theatrics than reasoned discourse, the trial nonetheless had a significant impact on biology education in the United States.(8)

Although the Scopes Trial brought the controversy over biology education to a head, the antievolution campaign had an early impact on the material presented to American biology students. In 1924, a year after a national committee of educators had recommended evolution as one of nine major units to be covered in high school biology courses, several new biology texts were published, all of which treated evolution in a very reserved manner. As the decade continued, with increasing attention paid to the various campaigns to rid the public schools of evolutionary teaching, succesful biology texts downplayed evolution and related topics. The word "evolution" disappeared from the indexes of these texts, and Darwin himself was frequently expunged from the discussion of the history of biology. An interesting example of the fading status of evolution may be found in two editions of the widely-used text *Biology for Beginners* by Truman Moon. The frontispiece of the 1921 edition was a portrait of Charles Darwin. The edition published five years later replaced the Darwin portrait with a cutaway drawing of the human digestive system.(9)

As pointed out by Judith Grabiner and Peter Miller in 1974, this "self-censorship exercised by the New York-based publishing industry" shaped the teaching of high school biology until the late 1950s. The economic considerations which guided these publishers' decisions were in turn guided by various characteristics of the biology text publishing business. The largest markets for text publishers were those states (mostly in the South) which had statewide adoption policies. As the South remained the most militantly antievolution region throughout the 1920s, text publishers geared their offerings to a market which would more than likely want evolution downplayed in texts. Characteristics of biology text publishing on the national level also played a role in the deterioration of biology education. For the most part, professional biologists were not involved in the writing of high school texts. Not only did this situation make it unlikely that the most recent biological knowledge would be included in texts, but it also left the door open for textbook writers to emphasize the practical, human welfare aspect of biology. Hygiene and similar topics proved far more important than evolution.(10)

Once established as a result of the antievolution campaigns of the 1920s, the new view of biology education took on a life of its own. Educators and textbook writers alike embraced the concept of meeting the needs of the students through an emphasis on health information and consumership. Evolution and other "theoretical" concepts were largely ignored. Although rarely involved with the writing of textbooks for high school biology courses, professional biologists nonetheless expressed concern with biology teaching during the 1930s. Writing from Indiana University, Alfred C. Kinsey told readers of *School Science and Mathematics* that he was well aware of the conflicting opinions concerning the subject matter of high school biology courses, but remained concerned with the practical focus which seemed to be taking over the curriculum. While admitting the importance of teaching hygiene, for example, he questioned the high school biology course as an appropriate forum for such instruction. "From a biology designed to interest future citizens in the living world about them, and calculated to introduce those citizens to a scientific method," Kinsey argued, "we are at best directing their attention to a species of toothbrush biology suspiciously fortified with the trappings of articles of personal faith." Later in the decade, Kinsey authored both a text and a science methods book in which he emphasized evolution as an integral part of biology which should be taught at the high school level. Bowing to political realities, however, Kinsey stressed that evolution should be taught very carefully and that human evolution should be ignored.(11)

Perhaps the most outspoken critic of the inadequate teaching of biology in America during the post-Scopes period was Oscar Riddle. A member of the Carnegie Institution of Washington's Station for Experimental Evolution at Cold Spring Harbor, New York, Riddle had become sufficiently dismayed at the status of biology education in the United States that he devoted his vice presidential address to the topic at the American Association for the Advancement of Science meeting. Addressing the zoological sciences section on 1 January 1936, Riddle surveyed recent progress in the study of zoology as it related to evolution while contrasting the public's almost total lack of knowledge of such developments. Riddle emphasized that biologists had failed to disseminate the new information to the public. Only by such dissemination could they forestall antievolution and anti-vivisection campaigns, to cite two of the most dramatic. He continued his argument by pointing out that the antievolution movement in America was not dead, as shown by poor biology texts, the lack of public understanding of biology in general and evolution in particular, and substandard biology teaching. In fact, he argued, secondary schools currently taught less biology than in the early years of the century, despite significant developments in biology itself. Among the cures for this dismal state of affairs, the proper training of biology teachers was high on Riddle's list. "The presumption that for making a teacher of biology there is any substitute for long-continued training under our best college biological departments is an expensive fraud," he argued, "and the extent to which that presumption is being enforced in one or another guise is now an educational disgrace."(12)

In an attempt to determine the quantitative dimensions of the status of biology in secondary education, Oscar Riddle distributed questionnaires to several thousand science teachers throughout the United States in 1940. Funded by the Carnegie Corporation of New York, Riddle's survey brought over 3000 responses representing all states and a representative cross-section of community types. Although biology was the best established scientific discipline in secondary schools, biology teachers were exposed to conflicting pressures in their attempts to maintain or increase their subject's presence. Student demand and the subject's practical aid to agriculture, forestry or health supported efforts to increase the amount of biology taught, but negative pressures came from the belief that biology was too difficult for high school students, administrative objections to the cost of laboratory materials and the desire for larger numbers of "commercial" courses in the curriculum. Given that insufficient support for expansion of the biology curriculum existed, biology teachers thus had to fit their subject into existing conditions. Riddle's survey suggested that such decisions were based on inadequate preparation, as only slightly more than half of the teachers responding had special training in biology. As a result, biology teachers tended to stress such topics as physiology, health, disease, hygiene and conservation, with occasional detours to the practical aspects of genetics and heredity. The refusal to teach biology as science led Riddle to characterize biology education as "a way to pleasing hobbies" or "a series of practical technologies." While admitting the value of hygiene and other practical topics, Riddle stressed that such applications of biology should only be taught after the basic principles were presented. He suggested adding another year or perhaps two to the biology curriculum so that both principles and applications could be taught.

Riddle's survey also gave a chilling portrait of the status of evolution in secondary biology teaching in the 1940s. The raw data from his sample suggested that no more than half of the nation's biology teachers taught evolution as a fundamental principle underlying plant, animal or human development. Reasons given for de-emphasizing evolution included the opposition of school boards and school administrators, although the opposition of the majority of the local community was cited most frequently by the teachers themselves. Teachers frequently cited personal belief as a reason for not teaching evolution, with several respondents incorrectly stating that it was against the law to teach evolution in their states. As bad as the situation appeared, Riddle emphasized that it was probably much worse. Southern, parochial and rural schools were underrepresented in the sample, leading Riddle to conclude that far less than half of the biology teachers in America paid sufficient attention to evolution in their courses. Even when evolution was taught, Riddle concluded, "this principle is frequently diluted beyond recognition, or it is so joined to traditional beliefs as to preclude a new ripple of thought."(13)

The criticisms of American science education typified by the comments of Riddle and others became more evident following the end of World War II. The clear importance of science to the war effort led to several examinations of the role and quality of science education in the United States. The President's Scientific Research Board published a report in 1947 entitled Science and Public Policy which emphasized the serious shortage of secondary mathematics and science teachers. This report urged not only the training of more science and mathematics teachers, but also stressed the need for an expanded science curriculum for these future teachers.(14) Such expressions of concern, however, had little impact on the biology classroom. Although biology was well established as part of secondary education by 1950, with almost all American high schools offering a general biology course of some description, the status of evolution within the curriculum remained problematical. A study of biology teachers in Essex County, New Jersey, for example, disclosed that nearly thirty percent of those responding failed to discuss evolution as a regular part of their classes. An equal number of those New Jersey educators returning the questionnaire admitted their belief that "organic change is the effect of supernatural causes, i.e., a divinely guided process." California educators showed similar characteristics in 1951, when a third of the state's biology teachers deleted evolution from their courses.(15)

The textbooks of the decade provided little assistance to those who might wish to improve the quality of biology education. Driven by marketing considerations, publishers continued to downplay evolution. Most of the texts published during the 1950s were revisions of pre-war texts characterized by even less coverage of evolution than in the 1940s. Those texts which included a chapter on evolution usually placed it near the end of the volume, where it could be deleted from the course most easily.(16)

In addition to the inadequacies of textbooks, the training of biology teachers during the 1950s continued to represent a major problem, as emphasized by Oscar Riddle in an American Biology Teacher essay in late 1954. Stressing how to teach, as was the practice in the various schools of education in America, failed to equip people concerning what they should teach. Education in general, and especially science education, was largely failing in its responsibility to the United States. For the most part, Riddle argued, "we Americans are uninformed; worse, we are complacently drifting on or within the borders of anti-intellectualism. We are post-graduates only in gadgetry and in the hoopla and skills of production, sports and marketplace."(17)

Despite Riddle's warnings, the teaching of biology remained mired in mediocrity. Scientists and educators concerned with the problem recognized that the shortcomings in biology education were part of a more general lack in the teaching of science in America. Describing such teaching in the 1950s as "anti-intellectual," "soft" and "behind the times," critics charged that American science education had failed in every important aspect because it did not "teach real science."

Among the most important factors influencing the poor quality of biology education in the United States was the questionable preparation of biology teachers. Various surveys and analyses indicated that many individuals who taught biology in the secondary schools were not even biology majors, but rather individuals who had majored in "science education" or who had taken only enough biology courses to satisfy minimal state certification requirements. Throughout the decade, the institutional shortcomings in biology education were compounded by the decline in the number of biology and other science majors who wanted to teach at the secondary level. As a result, at no time during the 1950s was it possible to fill more than a fraction of teaching positions with well-qualified science graduates.

Concerned biologists and educators began to consider ways to improve the situation by the middle of the decade. Various curriculum committees examined the teaching of tenth grade biology as the opening salvo in the battle against mediocrity in the public schools. These reformers emphasized that a more integrated course built around an interpretive theme was crucial for any meaningful improvement. The need to improve laboratory work and the desirability of new teacher training programs were also stressed. Increasingly, research biologists participated in these considerations and integrated the most recent results from the academic community.(18)

Although the formation of curriculum committees and study groups and the organization of various teaching conferences represented an encouraging sign for American education, science education in the United States had nonetheless reached a crisis point by the second half of the 1950s. The crisis in American science education was dramatically brought to the attention of the public and the nation's policymakers by the successful launch of the Soviet satellite Sputnik in October of 1957 and the failure of the American Vanguard satellite a few weeks later. Since the end of World War II, the United States had appeared to be the world's scientific and technological leader, an assumption which seemed warranted from the rapid growth of the American scientific community and the availability of large sums for research and development. The shock of Sputnik called the nation's scientific pre-eminence into question and led to significant self-analysis of the American educational system. Fundamental weaknesses in this educational system, especially as they related to science, could no longer be ignored.

Recognizing the political and security implications of the situation, the Eisenhower administration led the way in making improved science education a national priority. Beginning in the fall of 1957, the National Science Foundation became an active partner in the campaign to revitalize the teaching of science in American public schools. Its first effort focused on the study of physics, clearly a vital topic in the newly-inaugurated Space Age. The Physical Science Study Committee initiated a national re-examination of the teaching of science which would soon spread to other disciplines, including biology. Galvanized by the Sputnik crisis, the nation committed itself for the first time to significant improvement in science education. The national concern was mirrored at the local level as well, as principals and science teachers attempted to change existing programs. In biology, this change frequently involved the addition of an advanced course for those students especially interested in life science.(19)

Despite calls for educational reform, the teaching of biology continued to suffer from a particularly vexing problem. In order to present biology in an accurate fashion, teachers would have to deal with the topic of evolution, which represented the unifying theme in the discipline. Addressing the Central Association of Science and Mathematics Teachers in late November, 1958, Nobel laureate Hermann J. Muller declared, "One Hundred Years Without Darwinism Are Enough." In a carefully constructed essay which gained significant attention in its later published form, Muller criticized the lack of evolutionary teaching in the public schools for creating a faulty view of the biological world. He disarmed the objection made by many antievolutionists that evolution was "merely a theory," by emphasizing that "nothing whatever can be or has been proved with fully 100% certainty, not even that you or I exist, nor any one except himself, since he might be dreaming the whole thing." Evolution, though, had been confirmed by so many different discoveries in the century since Darwin published Origin of Species that to suggest that the theory represented anything other than a fact was ludicrous. Stressing the importance of science education in the ongoing competition with the Soviet Union, Muller challenged teachers to do more in terms of curricular revisions to establish evolution in the public school biology class where it clearly belonged.(20)

The fall of 1958 marked a milestone in biology education in the United States with the announcement by the National Science Foundation of a $143,000 grant to establish the Biological Sciences Curriculum Study (BSCS). With contributors such as Hermann J. Muller, Joseph Wood Krutch, George Gaylord Simpson and many other famous biologists, as well as a separate headquarters at the University of Colorado, BSCS promised to revitalize the teaching of biology. By the time of the first meeting of the steering committee in February of 1959, participants in the program decided that the focus should be on the tenth grade biology class and the rapid development of materials for teacher and student use in such classes. As this biology class frequently represented the only science course high school students took, the class was defined as a general education biology course for the average citizen. In addition to emphasizing science as a process of knowledge, rather than as an accumulation of facts, members of the steering committee agreed not only that evolution should be an important part of the reformed biology classes but also that it should be one of nine themes which ran through the entire course. Indeed, the status of evolution in any biology course was never questioned.(21)

By the fall of 1963, after extensive testing and modification of the various BSCS materials, the new program began in school districts throughout the nation. Early results indicated that BSCS students did significantly better on various tests than did non-BSCS students. Within a few years of their introduction, BSCS materials were being used by nearly half of all high school biology courses in the United States. Increasingly, too, non-BSCS texts began to resemble the new material, even including evolution in their discussions and involving increasing numbers of professional biologists in the composition and review of such texts.(22)

Despite the success of the BSCS programs, the status of evolution in American public education failed to change overnight. A 1961 questionnaire sent to a thousand high school science teachers revealed the startling statistic that two-thirds of the teachers surveyed believed that a teacher could teach biology effectively without accepting evolution. Later in the decade, a survey of Indiana high school biology teachers indicated that BSCS materials did not always have an immediate impact. More than sixty percent of those surveyed agreed with the statement that evolution was a theory and therefore could not be said to have definitely taken place, while a third of the respondents clearly stated that they did not think evolution was a fact.(23)

The BSCS program nonetheless had a noticeable effect on the teaching of biology in the United States, even if evolution remained a controversial issue in some areas. In light of the improvements in secondary biology education, many colleges by the mid-1960s had reorganized their introductory biology courses, offering one course for those students who had studied BSCS materials and a less sophisticated course for those who had not. By the end of the decade of the 1960s, the $10 million provided BSCS by the National Science Foundation and other agencies appeared to have contributed significantly to the improvement of biology education in the United States. Writing a memoir of the first decade of the BSCS program, Arnold Grobman prophesied in 1969 that, "It appears now that the major storms are over. There is every indication that the teaching of evolution is generally accepted in America and will become far more commonplace than it ever was before."(24)

He could not have been more wrong. Although the new biology curriculum was well established and the remaining antievolution statutes were eliminated, by the late 1960s the opposition to the teaching of evolution had taken on new life in a different form. The presence of evolutionary material in the new biology texts precipitated a predictable reaction on the part of religious conservatives, who embraced the so-called "creation-science" as a valid scientific alternative to evolution. Arguing that evolution was nothing more than a guess, creationists stressed that there existed as much scientific evidence for the Genesis account of creation as for the Darwinian theory taught in the nation's textbooks. They proposed that if evolution were taught, creation science should be taught in an equally forthright fashion. Such demands for "equal time" attracted the attention of legislators and local school officials, who usually had no more appreciation of scientific concepts than the students who would be exposed to such questionable teaching. Publishers quickly recognized that the nation was again hostile to evolution and began to eliminate the topic from textbooks. Although statutes attempting to establish the "equal time" concept have been declared unconstitutional by the U.S. Supreme Court, local school boards and individual teachers have nonetheless incorporated creationism into the biology curriculum.(25)

An examination of the historical dimensions of biology education in the United States suggests that the current crisis is rooted in fundamental weaknesses which have long characterized such education. Throughout the twentieth century, biology education has generally remained at a very low level, with only occasional advances beyond academic mediocrity. The BSCS program represented biology education at its best, but opposition to evolution and the discussion of reproduction soon eliminated the possibility of permanent reform. The past two decades have been characterized by further deterioration, with students increasingly unaware of fundamental knowledge concerning terrestrial life. A recent survey showed that significant numbers of biology teachers held erroneous views, such as the belief that dinosaurs and humans lived at the same time, suggesting that our present difficulties have disturbing parallels to the pre-Sputnik era.(26) Calls for reform in biology education must therefore take into account the historical aspects of the current crisis before any meaningful improvements can be proposed.

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Attitudes, Problem Solving, and Mental Imagery Factors in Middle School STS Science Education

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Introduction

This is the second of two papers presented at the 5th Annual Technological Literacy Conference discussing work at Potsdam College on STS Science Education at the middle school level. In the first paper, a framework for understanding STS Science Education for Minority Students was developed, and the utility of various assessment instruments was discussed.[1] Here, the results of field tests of assessment instruments are presented.

The objective of this study was to examine interdependence between cognitive, metacognitive, and affective factors associated with STS Science Education, and to investigate the effectiveness of a new measure. The goals of STS Science Education focus on preparing individuals to utilize science for improving their own lives, and enabling individuals to deal responsibly with science related social issues. Realization of those goals require that attitudes, social decision making skills, and cognitive abilities be nurtured in schools.[2] The new assessment measure used in this study is unique in two ways. 1) It utilizes the microcomputer to interactively assess mental imagery, cognitive functions and problem solving abilities, providing for their measure in a technological medium. 2) The theoretical context of the instrument was selected for its ability to include common components of social reasoning, science inquiry, and science problem solving skills.[3] This approach provides insight into the common denominator of the cognitive, metacognitive, and affective goals of STS Science Education.[4]

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[1] Doody, W. "STS Science Education For Minority Students, A View Through The Prism of Values and Intellectual Development". Paper Presented at the 5th Annual Technological Literacy Conference, 1989.

[2] The middle/junior high school years are pivotal with respect to the formation of lasting attitudes and values, and research shows that during those years attitudes towards science decline significantly. James, R. & Smith, S. 1985; Atwater, M. 1987.

[3] op. cit.

[4] further discussion of those goals at the middle school level; Doody, W. & Robinson, D. 1987.

The Study

Two samples of middle school students were selected from two different school districts. Sample #1 (n=21) was comprised of advanced eighth graders enrolled in Regents Earth Science. This sample is characterized by high achievement; other characteristics of the sample include family income in the lower middle SES bracket, and Caucasian ethnic grouping. Sample #2 (n=98) was comprised of seventh graders in a school district having a population of 50% Native Americans and 50% Caucasians. The SES profile of this population was similar to that of the other sample. Both samples were drawn from school districts from small town / rural areas, where the largest town had a population of approximately 35,000. Industries in the school districts included mining, hydropower, and Aluminum smelting.

Sample #1 was administered the Microcomputer test[1] and the GALT test of logical thinking[2] (table 1). Sample #2 was administered the Microcomputer test, the Middle Grades Inquiry Process Skills Test (MIPT)[3], and a test of attitudes. Year end grade in science for sample #2 was also utilized as a measure of achievement. Results for this sample are presented in tables #2 through #5.

Those tests assess the following. The Microcomputer test assesses level of development of mental imagery (Simple Imagery and Analytic Thought Utilizing Imagery), cognitive functions (entailing identification of cause - effect relationship, and proportional reasoning), and problem solving (identifying variables, hypothesis formation and testing, and rule determination). Imagery and functions test items are drawn from Piaget, while the problem solving item is drawn from Bruner.[4] The GALT test assesses the logical thinking skills associated with conservation (mass and volume), controlling variables, proportional reasoning, probability, permutations and combinations (drawn from Piaget). The MIPT test assesses the integrated science process skills of stating research questions, stating hypotheses, identifying variables, designing an investigation, constructing data tables, interpretation of graphs, and drawing conclusions (with original SAPA definitions refined by research). The attitudes test assesses Self Concept, Self Achievement Motivation, Attitude Towards Science Teacher, Science Anxiety, Family Attitude Towards Science, and Friends Attitude Towards Science.

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[1] the development of this instrument is more fully discussed in Doody, 1989, op. cit.

[2] Roadrangka, Yeany, & Padilla 1983.

[3] Padilla & Cronin, 1986.

[4] Piaget et. al. 1971 and 1977. Bruner et. al. 1956.

Table 1
(Sample 1)

Correlation Matrix for Variables: $X_1 \dots X_{11}$

	Simplel...	Analytic...	Cognitiv...	Bruner	GALT1&2	GALT3&6	GALT4&5	GALT7&8
SimpleIm...	1							
Analyticl...	.031	1						
Cognitive...	.085	-.203	1					
Bruner	.234	.254	-.506	1				
GALT1&2	.022	-.23	.372	-.675	1			
GALT3&6	.269	.101	.309	-.091	.261	1		
GALT4&5	.055	-.09	.177	-.03	.13	.359	1	
GALT7&8	-.248	.169	-.046	.047	-.171	-.116	.03	1
GALT9&10	-.134	-.348	.086	-.266	.188	-.005	.279	.016
GALT11...	.063	-.151	.407	-.183	-.194	.015	-.201	-.23
TotalGalt	.016	-.142	.398	-.324	.357	.624	.688	.273

Table 2
(Sample 2)

Correlation Matrix for Variables: $X_1 \dots X_{12}$

	Simplel...	Analytic...	Cognitiv...	bruner	rschQuest	Hypothe...	ID vars	R Design
SimpleIm...	1							
Analyticl...	.088	1						
Cognitive...	.207	.145	1					
bruner	-.019	.012	-.292	1				
rschQuest	.16	.164	.207	-.137	1			
Hypotheses	.175	.256	.247	-.125	-.105	1		
ID vars	-.017	.213	.213	-.239	.235	.177	1	
R Design	.101	.275	.242	-.14	.059	.527	.274	1
Data Tabl...	-.131	-.111	.097	-.26	-.047	-.109	.105	.053
Graphs	.073	.111	.336	-.232	-.034	.152	.299	.293
Conclusion	.139	.084	.074	-.106	.243	.39	.04	.309
MiptTotal	.151	.287	.371	-.316	.362	.62	.572	.714

Note: 24 cases deleted with missing values.

Table 3

(Sample 2)

Stepwise Regression Y_1:SciAchievement 5 X variables

STEP NO. 1 VARIABLE ENTERED: X_3: Mipt1234

R:	R-squared:	Adj. R-squared:	Std. Error:
.47	.221	.21	1.064

Analysis of Variance Table

Source	DF:	Sum Squares:	Mean Square:	F-test:
REGRESSION	1	22.187	22.187	19.596
RESIDUAL	69	78.123	1.132	
TOTAL	70	100.31		

Stepwise Regression Y_1:SciAchievement 6 X variables

(Last Step) STEP NO. 2 VARIABLE ENTERED: X_6: CognitiveFunction

R:	R-squared:	Adj. R-squared:	Std. Error:
.515	.265	.243	1.041

Analysis of Variance Table

Source	DF:	Sum Squares:	Mean Square:	F-test:
REGRESSION	2	26.586	13.293	12.261
RESIDUAL	68	73.724	1.084	
TOTAL	70	100.31		

Table 4
(Sample 2)
ANOVA

The AB Incidence table on Y_1: SciAchievement

	gender:	male	female	Totals:
ethnicity	caucasian	34 3.088	18 2.611	52 2.923
	NativeAme...	18 3.056	24 2.208	42 2.571
	Totals:	52 3.077	42 2.381	94 2.766

The AB Incidence table on Y_2: AnalyticImagery

	gender:	male	female	Totals:
ethnicity	caucasian	34 264.676	18 198.889	52 241.904
	NativeAme...	16 172.438	24 222.292	40 202.35
	Totals:	50 235.16	42 212.262	92 224.707

Table 5
(Sample 2)
Correlation of Attitudes

	Sci.Teacher	Sci.SelfCon.	Gen.SelfCon.	Sci.Anxiety	
Fam.AttitudeSci	.22	-.41	-.35	-.27	Native
SelfAchiev.Motiv.	.14	.09	-.35	-.13	American
FriendsAttitudeSci.	.47	-.27	-.18	-.21	Males
Fam.AttitudeSci.	.33	.10	-.03	.12	Native
SelfAchiev.Motiv.	.58	.52	.19	.47	American
FriendsAttitudeSci.	.36	-.17	.27	.32	Females
FamAttitudeSci.	.50	.41	.50	.23	Anglo
SelfAchiev.Motiv.	.33	.36	.17	-.03	Females
FriendsAttitudeSci.	.53	.61	.14	.02	
FamAttitudeSci	.42	.40	.67	.33	Anglo
SelfAchievMotiv.	.31	.56	.31	.07	Males
FriendsAttitudeSci	.60	.57	.25	.23	

Results

Among high achieving 8th grade students, significant correlations exist between scores on the total GALT test and the Cognitive Functions and the Bruner portions of the Microcomputer test. The Cognitive Functions items involve observation of cause effect relationships between weights added to a pan balance and movement of a spring, and proportions involved in the rotations of wheels of different size and distances traveled. The Bruner problem consists of a classic "concept attainment" problem involving identification of variables, hypothesis generation, rule identification, and problem solution. Low scores (number of attempts made) on the Bruner problem indicates quick success, while high scores indicates failure to solve the problem. Cognitive Functions scores were most strongly related to GALT test items involving permutations and combinations, and conservation of mass and volume. Bruner test scores were most highly related to the GALT test items of conservation of mass and volume.

The Cognitive Functions and Bruner test scores were also significant correlates of MIPT test scores for sample 2. The MIPT skill of graphing was particularly related to Cognitive Functions score. The Bruner test score did not correlate highly with individual MIPT items.

Stepwise multiple regression on Science Achievement indicated that the principle correlate of Achievement was the sub score for MIPT items 1,2,3,& 4 (range = 0 - 8). On step two, Cognitive Functions (range = 0 26) was entered. No other variables passed the test of F = 4.0 to be entered into the regression.

Analysis of variance, using groups defined by ethnic group and gender, indicated that two significant differences existed. Males achieved higher than females; Native American Males were significantly poorer than Caucasian Males in Analytic Imagery. No gender related differences were found on MIPT scores or Microcomputer scores. On the Attitudes measure, Native American Males were significantly different than other groups, but this did not translate into an achievement difference.

Conclusions

The above results may indicate that sources of group differences in science achievement are due to a more complex set of variables than those of Attitudes, Intellectual Ability, and Science Inquiry Skills. While Native American Females and Caucasian Females were no different from males in MIPT skills and in Attitudes, they nevertheless achieved less. While Native American Males were significantly different in Attitudes from all other groups, and while they alone performed poorly in Analytic Imagery, their achievement was equal to that of Caucasian Males. Interestingly, Native American Males exhibited good inquiry skills on the MIPT measure of Graphing and Data Tables, while doing poorly in Analytic Imagery. The latter is a measure of symbolic thought (whereas Simple Imagery assesses visual decontextualization skills), and might be supposed to be necessary for Inquiry Skills and achievement. Discussion with Native American Community leaders revealed that some Native American men work in construction involving reading of blueprints, and that some of these same men have poor reading and math skills, but excellent ability in reading and using blueprints. Additional Microcomputer test data supports the inference that inquiry skills development precedes (but does not assure) development of cognitive operational abilities. Piaget's Cognitive Functions are analogous to inquiry skills, and in those the Native American males did well on the Microcomputer test. This suggests that it may be useful to focus attention on establishing clear educational objectives in the domain of cognitive operations in addition to clear objectives in the domain of cognitive skills. This conclusion suggests that the same may be true of issue identification and decision making skills. Skills development precedes (but does not assure) development of cognitive operations. In as much as good judgement depends upon operations of thought, it is necessary to establish clear objectives in each domain if STS goals are to be realized.

Females, who in this sample had superior symbolic reasoning ability, good inquiry skills, and positive attitudes, nevertheless had lower achievement levels. Additional factors which must be further investigated include culturally influenced goals and values, which must be defined by both ethnic group and gender.

Finally, it should be noted that the science learning environment for these students is exceptionally good. Scores on the test of attitudes indicate very good self concept in science, very good attitude towards the science teacher. This population (sample #2) is also particularly sensitive to and interested in STS issues; they are very verbal about local environmental issues, and very vocal in local, state, and national politics.

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UNIVERSITY PROGRAM IMPERATIVES ON TECHNOLOGY AT THE UNDERGRADUATE AND GRADUATE LEVELS

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As technology and technological literacy become a focus for education and educational frontiers, there suddenly are many players on the stage. Conferences, councils and seminars have been populated by philosophers, engineers, historians, congressmen, sociologists, economists, scientists, and various sprinkles of educators from kindergarten teachers to professors, from English to industrial arts, and from agriculture to vocational education.

Yet, there has been limited impact and implementation in the educational environment. Funded programs, professional societies, magazine publishers and organizations are stressing efforts to contribute to technological literacy but it is limited to segments of education or selected educational institutions which seems to promote certain discipline as professional areas.

This paper will focus on educational programs and a segment of educators that have technology and technological literacy as program imperatives or focus educational programs around content with innovative approaches for undergraduate and graduate programs. Presently, we are talking about technology education and/or industrial technology. These undergraduate programs currently serve three functions: preparation of teachers, a general education endeavor, and preparation of industrial personnel.

TECHNOLOGY EDUCATION AND GENERAL EDUCATION

The preparation of teachers for technology education programs has been under the rubric of industrial arts education since the early twentieth century. Only in this decade has it evolved into technology education. Technology education has been defined as:

> a comprehensive, action-based educational program concerned with technical means, their evolution, utilization, and significance; with industry, its organization, personnnel, systems, techniques, resources, and products; and their social/cultural impact (AIAA, p. 25).

The technology teacher is educated and prepared to establish instructional strategies, and develop content and experiences which acquaints every student with reasoning, problem solving, creating, constructing, operating, and expressing with tools, materials and machines. The philosophical foundation is to provide a basic and fundamental study for all persons, irrespective of educational or career goals. Technology education proposed by the ITEA as a program of study can help the student to:

- know and appreciate the importance of technology.
- apply tools, materials, processes, and technical concepts safely and efficiently.
- uncover and develop individual talents.
- apply problem-solving techniques.
- apply other school subjects.

- apply creative abilities.
- deal with forces that influence the future.
- adjust to the changing environment.
- become a wiser consumer.
- make informed career choices.

During this twentieth century, technology education has existed under numerous banners. Under practically all of these banners, the programs have proclaimed to be a component of general education. It has also espoused that all children should have these experiences. General education has been viewed as common experiences for all students at the secondary level of education. At times at the collegiate level, it has been recognized as liberal arts education. This has implied a broad acquaintance with the various segments of human knowledge and understanding. There have continually been times when concerns have arisen over the components of general education. Following WWII, a Harvard commission delineated its perspectives, a Presidential Commission established eleven objectives for general education, and in the recent decade, there have been many voices reiterating those concerns and questions again. The reports, the "Calls to Action", the "lacking" perspectives, and the prospective reforms have been directed to the education arenas, its discipline areas and other related educational audiences. However, the phrase, general education, remains ambiguous and its various interpreters have proposed different standards and different directions for reform. Gaff identified four approaches in the current debate: idealism, progressivism, essentialism, and pragmatism. In broad terms, these approaches all have similar and recognizable qualities, and so general education

- is rooted in the liberal tradition and involves study of the basic liberal arts and sciences;
- stresses breadth and provides students with familiarity with various branches of human understanding as well as the methodologies and languages particular to different bodies of knowledge;
- strives to foster integration, synthesis, and connectedness of knowledge rather than discrete bits of specialized information;
- encourages the understanding and appreciation of one's heritage as well as respect for other peoples and cultures;
- includes an examination of values---both those relevant to current controversial issues and those implicit in a discipline's methodology;
- prizes a common educational experience for at least part of the college years;

- requires the mastery of the linguistic, analytic, critical, and computational skills necessary for lifelong learning; and

- fosters the development of personal qualities, such as tolerance of ambiguity, empathy for persons with different values, and an expanded view of self. (Gaff. pp. 7-8).

Many of these qualities and experiences are related to the concerns raised by the reformers call to action. Presently, the social needs, a growing technology, the explosion of knowledge, and the proliferation of scientific inquiry have been the essence which requires the reformers to reassess our educational requirements. Coleman and Selby, in their report Educating Americans for the 21st Century, noted that "The world is changing fast. Technological know-how...along with the knowledge that such skills and sophistication are the basic capital of tomorrow's society. (1983)" Similar comments have prevailed in previous times of concern. Another perspective of this reorientation is succinctly stated by Ornstein, "A school that does not emphasize technology will miseducate students for the future. (p. 44)"

Technology must become an element in general education. Reports from the Commission on Excellence, the National Science Foundation, the National Academy of Sciences, and the Carnegie Foundation for the Advancement of Teaching are in accord that "scientific and technological literacy" should be a major component of a program of general education. Coleman and Selby stated that

> We must return to basics, but the "basics" of the 21st century are not only reading, writing and arithmetic. They include communication and higher problem-solving skills, and scientific and technological literacy ---the thinking tools that allow us to understand the technological world around us. These new basics are needed by all students.... (1983, p. v).

In a report on secondary education in America, Boyer recommended that

> ...all students study technology: the history of man's use of tools, how science and technology have been joined, and the ethical and social issues technology has raised (1983, p. 110).

This is the most recent example of the continuing effort to establish recognition that technology is an element of general education. Recently, at the collegiate level, many private liberal arts institutions are including courses with science and technology components and their societal implications on an interdisciplinary perspective as a general education course. Many of such courses have had a thematic concentration with a focus on a specific science/technology-related theme or problem with an interdisciplinary perspective. In the public institutions, the liberal arts, the arts and humanities, and the arts and sciences faculty have stoutly resisted such efforts and recognition. Bauman portrays this attitude as "Liberal arts has neither accepted technology as an extension of the human brain nor has it done its job of synthesizing the expanding world of knowledge. Many humanists still treat technology as though it were an alien invader...(1987, p. 39)."

It is not the intent of the writer to bash or be negative, but such collective views prevail and control education programs.

It is necessary to look at programs that have recognized that technology should be part of general education. These are efforts which were initiated from or eminating from the technology education or industrial technology department. Several public institutions have a general education course component focusing on technology that has been offered in a department of industrial education and/or industrial technology. St. Cloud State University has had such an offering since the mid-1960's. It was offered in industrial arts with an industrial arts instructor for an awareness of technology and its impact upon society. Bowling Green State University has also been embarked in a similar practice for over a decade. The University of Northern Iowa, since the mid-1970's, initiated a curricular and facility based around the concept of an industrial technology concept. A basic theory course was developed for industrial arts majors in a large group lecture setting with various audio-visual inputs and a nearby laboratory available for demonstration and small group instruction. These same courses were also available as general education for all other students, and focused on technological areas such as systems: communication, power and production. They provided a basic understanding of the technology employed in those systems, and the relationship and effect they have on man, society and the environment. Since there were three courses for three broad areas of technology, the content varied. The communication area consisted of printing (graphic arts) methods, photography, mechanical drawing (spatial representation), cinematography, television, radio, microwave and electronic devices. The power area included kinds of energy, power generation and transmission, and forms of transportation. The production sector considered manufacturing, construction and fabrication, materials processes, machines/devices, organizations to accomplish work, production of goods, and services. Descriptions, examples, models, patents, illustrations, and demonstrations were presented. Histories, persons and their contributions, impact on culture and society, changes made, and geographical factors were infused into readings, papers, discussions, films, and lectures. Aspects of industry were also included, such as, the standard industrial classification system, stock and forms of ownership, corporate structure, and the organizations that accomplish basic research to production and marketing and distribution. A revised general education program required a change to a capstone course. This course is for the upper division level building on lower division courses from the various science departments. It uses a case study approach and focuses on environmental issues in order to demonstrate interrelationships and interactions among science, technology, and society. Thus, because of the topics that may be selected for focus and consideration, there is no set content established. A further prospective development will focus on a broad technology awareness and the relationships on society.

A DOCTORAL PROGRAM FOR INDUSTRIAL TECHNOLOGY

At the graduate level, a doctoral program has been in operation for almost ten years which has had a different designation and approach than normal doctoral degrees. This is the Doctor of Industrial Technology degree at the University of Northern Iowa. It is a program which focuses primarily on the preparation of instructors for higher education programs and industrial personnel. Such practitioners for careers and employment both in and outside of higher education institutions have ranged from professors to public administrators to industrial training managers and production management. This expansion of career preparation beyond education is supported by Bowen (1981) who advocated that new attitudes toward graduate education must be developed, especially toward non-academic pursuits.

While the D.I.T. program focuses on practitioner preparation, there is also a significant portion of the program devoted to research and research-oriented aspects. This program emphasizes scholarly research and applied practice in the field of industrial technology. The focus on both research and profession-orientation is not only different in approach but honest. Numerous studies (Wolansky and Miller, (1981) Buffer, (1979), and Brown) indicate that there is little difference between the Ph.D. and the Ed.D. Brown et al (1985) in a major study to identify quality elements in doctoral programs, reported that the Ph.D. has been and continues to be the preferred degree with the only distinction as the occupational goals, even though the degrees have little difference between them.

Program Characteristics

In attempting to discern the characteristics of doctoral programs, only the Doctor of Philosophy, Doctor of Education, and Doctor of Industrial Technology degree programs were analyzed. Many of these programs are usually identified as categorized in the professional field of education (many sources, the National Center for Educational Statistics, U.S. Department of Education, the American Council for Education, and the National Board for Graduate Education categorize disciplines and professional fields). Therefore, many programs in our areas are recognized as subsets of education. In reporting on the doctoral degrees granted in a ten year period, Wright (1977, p. 10-11) indicated that there were 28 fields. These would be various fields reported by institutions, such as industrial arts, technology education, or vocational-technical education. Industrial technology was not identified in this work. The use of terminology has lacked uniformity, preciseness, and clarification while differing in historical and philosophical terms, and so Harris (1977) utilized the term industrial education as it "...is a generic name for the academic areas of Industrial Arts Education, Trade and Industrial Education, and Technology" in his study. The Industrial Teacher Education Directory compiled by Dennis (1987) also varies greatly but includes vocational education and numerous variations or subsets. Thus, for this discussion, industrial education will include industrial arts or technology education, vocational education.

Industrial technology, while not as ambiguous a term, has been lacking in preciseness or definition. Recently, the National Association of Industrial Technology provided its definition: a baccalaureate program of study "...to prepare management-oriented technical professionals in the economic-enterprise system."

Description of Characteristics

The characteristics may be the distinquishing traits, features, or properties of doctoral programs. In a national study intended to assess the quality of doctoral programs, Brown et al (1985) identified and described doctoral program characteristics: residence and admission requirements, qualifying examinations, foreign language requirements, course and program requirements, research methods and techniques, dissertation, and cognate areas.

An earlier study analyzed industrial arts education graduate work based on the functions identified by the ACE. These four functions were defined as areas of competencies by Miller and Ginther (1965). Each function had its components described. These functions were: specialized technical competencies, research competencies, teaching and administrative, and general and liberal education.

A comparison study of differences between the Ph.D. and the Ed.D. degree programs was conducted by Wolansky and Miller (1981). This study analyzed components such as program requirements and options as well as differences in programs established prior to 1965 and those established later. Also conducted in 1981 by Koble, was the study to gather opinions regarding the quality of doctoral programs in industrial arts education. The findings were reported as rankings for the three highest and three lowest ranking programs, and describing the distinquishing characteristics for each group. Wright (1986, p. 214-215) focused on technology-based doctoral programs and then developed a model format along the lines of goal intent, the Ph.D. for research, the Ed.D. for practice, and the D.I.T. for research and practice in industry or education. He further noted that such doctorates should be focused on the study of technology and its implications for humankind in the present and in the future.

The D.I.T. program at the University of Northern Iowa is intended to pursue the following goals:

- provide the doctoral student with the intellectual tools necessary to pursue scholarly research and applied practice in industrial technology,

- offer an individually planned program of studies for the student, targeted at developing specific competencies toward designated career goals in industrial technology, and

- allow for the development of continued technical expertise and application of that technical expertise by each student.

In a presentation for industrial teacher educators, Fecik (1987) reviewed doctoral programs in this technical education area and analyzed the program characteristics of course requirements, research methods and techniques, dissertation, and cognate or support areas. Major groupings of courses were found to be: major field, core or foundations; research component or techniques; professional, specialization, concentration, or supporting field; and dissertation. The range of hours in each grouping had a wide range of divergence. The research component usually was comprised of two statistics courses, a research methods/procedures course, and a departmental research course. Other than the Ph.D., usually a computer science course could replace a statistics course. The specialization area could include courses within the department that permitted an in-depth preparation and seemed to usually consist of 12 hours. The dissertation usually includes only the dissertation and ranged 6-18 hours; at times, a seminar may also be a part of this grouping.

The D.I.T. program and its faculty are establishing an environment where doctoral students develop a knowledge and practice of:

- industrial technology as a discipline,
- the behavior of technological systems in industry and their effect on people and environment, and
- the potential and limitations of future developments in technological systems and their utilization in industry.

Some of the major expectations to be met for this degree program are established. The D.I.T. program:

- requires students who are mature professionals in the field of industrial technology,
- provides for technical expertise development within the department and the university,
- requires publication experience prior to dissertation proposal,
- requires industrial or educational internship (300 contact hours/6 semester hours of credit),
- and provides an individually planned program based on student written diagnostic tool - The Personal Career Development Plan (PCDP).

Some of these characteristics are similar to more traditional doctoral degree programs. There are some distinguishing traits that are not in such programs. The first trait, a mature professional, is crucial to the effectiveness of the program rigor. It is the student that must initiate the planning of the program, with an advisor, and delineate the career goals and document the competencies that are necessary to attain that goal upon graduation. It is felt that a person with professional experience would possess a perspective of clarity on personal capabilities and the intent of a career.

A second characteristic, technical development, is that courses and experiences for a technological area can become a segment of the program. The attainment can constitute an expansion of their present technical skills and knowledge, explore related or new areas of technology, or refine and develop a high level of expertise. This could be vital for the career objective of teaching at a four year institution as well as the managerial sphere in the industrial enterprise. This is an area that has not been traditionally part of graduate work. However, the advancement and sophistication of machines and technological devices has required a higher level of knowledge.

----------------------------DIAGRAM---

The student is required to have completed writing experience, usually a published article in a journal or periodical, before the proposal for a dissertation is accepted by the advisory committee. It is the intent that the doctoral student would demonstrate to their advisor and committee that a written treatise is acceptable for publication.

The required internship is an opportunity for the doctoral student to apply or practice previously gained knowledge in the environment concerning their career goal. The intern experience is usually done on site of the cooperating agency or industrial firm with support and supervision by the advisor. The internship is initiated with a proposal and requires approval by all parties involved. It may serve as an initial basic experience, provide a capstone attainment, or have a relation to the dissertation topic.

The most significant characteristic of the program is the Personal Career Development Plan. This written prospectus should be developed and approved by the advisory committee during residency. The PCDP is a prospectus which describes the nature of the career goal in competencies and supportive literature, a professional self-evaluation of competency attainment and needs, and the outline of courses and experiences through which competencies will be developed and constitutes the individually planned program.

The focus of the Doctor of Industrial Technology degree, then, is on developing those intellectual and practical competencies that are applicable as a career for the field of industrial technology. Like most doctoral programs, the goal of the D.I.T. is to contribute to the professional development of leaders in the discipline. Some of the components of the doctoral program, as discussed, are unique to each individual. The common core of experiences for the D.I.T. program is designed to provide the student with those knowledges and skills that will serve as a necessary foundation for a career goal in industrial technology.

The required part of the doctoral program is called the Core Program and is constituted by the following:

Industrial Technology Foundation	
Historical Developments in Industrial Tech.	3 sh
Contemporary & Future Developments in Industrial Technology	3 sh
Readings in Technology & Society	3 sh
Technology, Ethics and the Technologist	3 sh
Seminars	
Industrial Technology Seminar (Students must enroll in one-semester hour seminar during each summer session and semester while meeting residence requirements)	4 sh
Research, Statistical Methods & Computer Programming	
Research Methods in Industrial Technology	3 sh
Statistical Methods in Education & Psych.	3 sh
A Graduate Level Computer Course	3 sh
Internship	
Internship in Industrial Technology	6 sh
Dissertation	
Research	12 sh
TOTAL ..... Required Core Program	43 sh

Beyond these courses and experiences, the individual student will plan for specific competencies through specific courses and experiences. The total number of post masters semester hours required for the D.I.T. program is 64. Progression through the program is sequential and deliberate and places the emphasis on the development of the competencies detailed in the Professional Career Development Plan.

Courses of Significance

There are four major courses in the foundations core for the D.I.T. program. As listed above, they constitute a significant effort to establish a background regarding the characteristics of technology, its applications, the historical use of man's tools, machines, and materials, technological innovation, and the ethical and social issues that have evolved.

Various instructional strategies are employed appropriate to each course. The history course is a chronological analysis by time periods of technology, social developments and the implications arising from them. Usually a trip of several days duration is spent investigating a key technological item or artifact, its development, its heritage and antecedents, its innovations and its effects on society and culture. This student activity usually culminates with an illustrative panel, a research paper, and a slide presentation. And technology is traced across a timeline to illustrate its heritage, evolution and significance.

The contemporary and futures course has two focal aspects which are inherent in the course title. Technology assessment and technological forecasting techniques are examined and each student pursues a technique related to their technological area for future development and analysis simulation and modeling techniques on computers are also activities that are used.

The readings class was intended to be a capstone-style course to culminate the two previous courses. It is designed to have students investigate the literature on areas related to previous courses, their career areas of interest, and other technological concerns and issues. Each area is discussed in seminar style with analysis, debate and perspectives developed for implications and directions. A scholarly paper is another outcome to pursue an area in more depth and analysis.

The ethics course was added about five years ago in order to examine the values and ethics which concern our technological society. The issues, alternatives and decision-making are explored in view of societal, environmental, and career roles.

The program factors related to the career goals are the individually planned program which provides a flexibility unmatched in most other doctoral programs, and the continual research aspect which is an emphasis. Its general focus is on the study of technology, industrial technology and its implications for humankind.

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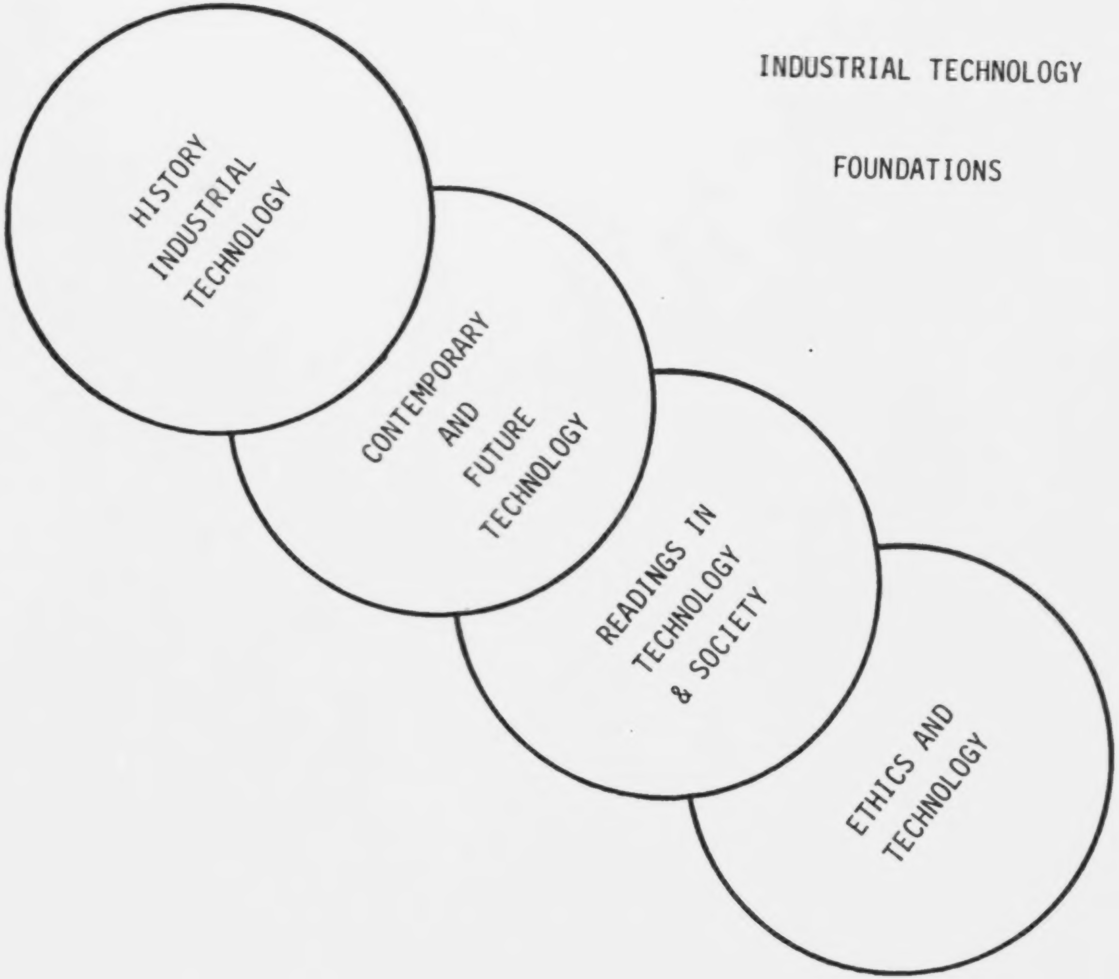
INDUSTRIAL TECHNOLOGY

FOUNDATIONS


HISTORY
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Technological Literacy and Teacher Education

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The technological literacy movement converges with the current drive for educational reform: both these movements have as their impetus a call to action that emanates from the industrial and corporate sectors of American society. To wit:

> Because changing conditions in international markets outpace the ability of American business and industry to control those markets.

-and-

> Because advances in technology, which will enable the U.S. to reassert its dominance of world markets, require that labor power be better educated than in the past, more amenable to technological innovation, and flexible enough to accommodate rapid changes in the employment market.

-therefore-

> If the American standard of living is to be maintained, the uncritical compliance of educators is required to prepare young people for the realities of life and work in post-industrial society.

One response to this call is the growing specialization of the curriculum, and particularly the promotion of computer technology in the classroom. We have witnessed the birth of a new field within education, often termed "computers in education" or "educational computing." My paper first discusses the current state of computer teacher education and the competing interests active in this new field. In the second part of this paper I shall critique the most powerful interest acting on computers in education: for-profit corporations and their drive to forge a new relationship between technology and education, a connection widely known as technological literacy.

My interest in this area was sparked when I prepared a proposal for a new seminar course intended for master's level students in their last semester of study. My specific charge was to encourage teachers-in-training to challenge their attitudes and opinions regarding the role of computers in the classroom and in society. My goal was for computer education students to recognize the forces that are shaping their field, forces that emanate primarily from outside education. And also to recognize the role of these forces in the interplay between public and private spheres of interest. My aim was to cast into high relief the relationship between technology and society which is so often blurred in our homes, our places of work, and our schools.

Corporate Rhetoric and Education

Teachers-in-training are caught in a web of competing interests: 1) proponents of computers in education; 2) critics of computers in education; 3) teachers who use computers in the classroom; and, 4) forces outside education, namely, the corporations currently clamoring for school reform. The voice of each of these interests makes claims on the attention of teachers-in-training. However, because of a note of ambiguity or because of a jargon-laden vocabulary or because of a partisan tone, these voices say little that is helpful to teachers-in-training. Let us take a minute to review these four voices that command the attention of computer teachers.

The first voice represents proponents of computers in education who typically research the efficacy of computer-based instruction (CBI), its long and short term effects on learning, and its appropriateness for certain populations and disciplines. This research includes analyses of the effectiveness of computer-based teaching and studies of the transition of CBI from research findings to teaching strategies. However, this research does not provide much direction to the field. As Bozeman and House, proponents who are concerned lest this new field die a premature death, point out in the T.H.E. Journal, and I quote, " Details of the specific nature of CBI and the particular context in which CBI was applied are often conspicuously absent in the research literature." Statements such as: "the unfulfilled promise of educational computing;" or, "the accomplishments of CBI are modest;" or, "educators have often failed to progress beyond the level of technological infatuation," are typical throughout the literature. More provocatively, a recent review of 287 research articles concludes: "there is no evidence to suggest that [computer-based instruction] is anything except an instructional placebo."[1]

The second voice, in addition to computer education proponents, is that of computer education critics. Among these critics are scholars who attack the philosophical bases of computers in education. Often, these scholars attack technology-based forms of instruction that mask the insertion into the classroom of political and social biases. Their most notable contributions include examinations of computer literacy as ideology and the extent to which computer instruction politically socializes children.[2] Important as they are, these analyses often depend on a specialized discourse and a critical frame of reference not easily accessible to teachers-in-training.

A third voice is that of teachers who already use computers in the classroom. Teachers often supply the data for the computer/student ratios, educational software reviews, and treatment/effect studies that are the mainstay of computer education journals. As such, these reports on the day-to-day realities of computers in the classroom serve as reference points for teachers-in-training. Unfortunately, however, these reports may not be the best indicators of how things really are. Indeed, if one scratches the surface of the day-to-day realities of computers in education, one often finds circumstances much different from those suggested by computer teachers. For example, in a recent study that included a questionnaire, lengthy interviews of teachers and administrators, classroom observations, and a review of computer-use log entries, large discrepancies were found between reports of computer usage and the observed time that students spent using computers. Instead of the 8.5 hours reported by their teachers, students actually used computers for about 45 minutes per week.[3]

While teachers struggle with the role and function of computers in education, a fourth voice -- stronger, more clear, and less ambiguous than the other three -- thunders down from the boardrooms of corporate America, pressuring teachers to move forward, to squelch the nay-sayers, and to make the schools "work". For the past several years we have often heard this voice mouthed by educators who sit on the various reform commissions, committees, and panels. Their charges range from "Johnny can't read" to "Sally can't do nuclear physics," and their message is clear: American education must change if the United States is to regain its position of dominance in world economic and political affairs. Proposals include the re-professionalization of teachers, the adoption of more efficient teaching methods using computers, and the redesign of the curriculum to cultivate those personal attitudes and intellectual habits deemed most likely to lead to success in the post-industrial workplace.

We've all seen snippets from these reports. For example, the report of the Carnegie Forum on Education and the Economy entitled A Nation Prepared, asserts that:

> America's ability to compete in world markets is eroding. The productivity growth of our competitors outdistances our own. The capacity of our economy to provide a high standard of living for all our people is increasingly in doubt. As jobs requiring little skill are automated or go offshore, and demand increases for the highly skilled, the pool of educated and skilled people grows smaller and the backwater of the unemployable rises.

And the report entitled Tomorrow's Teachers, prepared by the Holmes Group, a "consortium of education deans and chief academic officers from the major research universities," proclaims that "America's dissatisfaction with its schools has become chronic and epidemic." Such statements though, merely echo the corporate line. For example, Kay Whitmore, president of Eastman Kodak, said recently, "When we talk about today's educational system, there is a larger perspective we all must consider: What will it take to restore U.S. leadership in productivity, growth, and worldwide competitiveness in the 21st century." And David Kearns, chief of Xerox and current darling of the education crisis speakers' circuit, recently co-authored a book entitled Winning the Brain Race: A Bold Plan to Make Our Schools Competitive. Here, Kearns argues that educators must learn the lessons of the marketplace -- competition, discipline, and accountability -- to enable American workers to compete against their foreign counterparts, especially those in Japan.[4]

This rhetoric is arguably the most potent voice influencing not only computer teachers but all teachers today. Because such claims link education, employment, and technology they indeed deserve our further attention. It is interesting to note that, once again, education is highlighted in the corporate rhetoric while other social, economic, and political institutions remain submerged from view. Also out of sight is the role played by corporations in shaping public education to date. Submerged too are historical patterns of technological development which illustrate that technologies are shaped by social forces and do not shape themselves. These are all important issues, however, here, I shall focus on the role played by private corporate interests in the current drive for public technological literacy.

The Corporate Balancing Act

To understand this role, I will first describe briefly two key structural dynamics of the corporation itself. One key dynamic of corporations is the struggle to achieve internal balance. Imbalances occur when two principal internal corporate imperatives come into conflict. These imperatives are, (1) the reduction of risk through the maintenance of internal centralized authority and the systematic control of all relevant aspects of the corporate environment, and, (2) the promotion of entrepreneurial activity and "technical and organizational innovation." Embedded in these two corporate imperatives, stability and flexibility, is the potential for conflict. At different historical moments, either stability or flexibility may assume an overriding importance in the life of corporate organizations and threaten internal cohesion. As a result, corporations strive to develop internal consensus and to restore balance when the "need for flexibility" and the "powerful drive for stability" conflict.[5]

A second key dynamic of corporations is the interplay between public and private corporate spheres of interest. Tensions arise in this regard when internal corporate imperatives conflict with the public interest. For example, many corporate enterprises require that their agents manipulate "intangible symbolic assets," such as electronic fund transfers, on behalf of the public. Because by the very nature of these assets corporate agents "hold structural opportunities to take the money... and run," there are frequent abuses and violations of the public trust.[6] To ease tensions in this regard, corporations strive to develop external consensus. We experience this most frequently when corporate advertising reassures us that corporations and the public share common purposes. When these subtler forms of persuasion fail, corporate external consensus building efforts adopt the posture and ideological underpinnings of national mobilization campaigns. At the present moment, both of these corporate dynamics are in a state of tension: internally imbalanced and increasingly in conflict with the public interest.

Recently, the drive to innovate has been predominant and exaggerated in the overall behavior pattern of corporations, specifically innovation in capital manipulation coincident with the deregulation and internationalization of finance capital. Accordingly, a degree of imbalance is manifest in corporations. Such imbalance reverberates throughout the economy and shakes out winners and losers. Increasingly, the winners are corporate predators who pursue their prey wherever and whenever it is afoot. These corporate predators win by amassing capital to further corporate interests while leaving masses of debt in their wake. Witness the whirl of leveraged buyouts, the ubiquity of junk bonds, and the size of the national debt. Recent losers are the public, especially those with insufficient capital to participate in the markets, and, unsheltered taxpayers onto whose shoulders fall the responsibility to clean up after the corporations by providing bailouts for manufacturers, utility companies, and most recently, hundreds of savings and loan institutions. Speaking of bad loans, witness the distribution of investment capital among developing nations that has, in many cases, armed ethnic adversaries, financed the destruction of important ecological resources, and transformed entire national economies into interest-paying machines.

What accounts for the current emphasis on innovative capital manipulation? I suggest that this emphasis is an attempt to restore internal corporate balance after a long period in which corporations focused on preserving internal stability. The history of the smokestack industries failure, which is just now being told, provides evidence for such a suggestion. In many cases the upper echelons of smokestack corporations were filled with Nero's who fiddled while their operations burned out due to decades of poor maintenance and low rates of capital improvement. Meanwhile corporate resources were misallocated to internal empire-building and managerial prerogatives. A recent article in the Wilson Quarterly details how Bethlehem Steel's management developed a "corporate culture that had rewarded conformity and promoted insiders." One former Bethlehem executive explained, "We listened to our [own] propaganda for so long, we believed it."[7] Other research details how American manufacturers lulled themselves into complacency after years of financing their R&D efforts with fat cost-plus military contracts. In the case of computer-controlled machine tools, years of dependence on military funding taught the machine tool industry how "to avoid the hard work of efficient design and production."[8] Consequently, American-built computer-controlled machine tools became the most expensive in the world: the market for such machines was devastated. As Newsweek recently pointed out, to the extent that American manufacturers can recover, they must do so with foreign machines.[9]

The computer itself could not have been developed except for years of prodding -- with large bankrolls -- by the military. In the early 1950s, corporations such as IBM and NCR saw the market potential of computer technology as uncertain and considered investments in this new technology as too risky. The birth of the digital computer, which required tremendous innovation and entrepreneurialism on the part of large numbers of scientists and technicians, was accomplished almost solely with military dollars not as a consequence of corporate planning or foresight.[10] At the time, internal stability, not risk taking, was the corporate order of the day.

In the present, the failures of recent technological development have thrown sand in the corporate works and contribute to the alternate emphasis on innovations through capital manipulation. Development of the "high technologies" has been uneven. Automation technologies have not come on line as fast as predicted due to unforeseen difficulties in the development of robotics and artificial intelligence, not to mention the legacy of profligate military R&D contracts. And what about the second corporate balancing act between corporations and the public? Unexpected environmental consequences have invited public scrutiny. In some measure, public support for corporate agendas has come into question. As the National Research Council recently reported:

> ...antitechnology attitudes have become prevalent as public attention has focused on the growing capacity of technology for doing harm to individuals, the environment, and society itself. There have been many different concerns -the environmental and health effects of air and water pollution, problems of safety in the design of automobiles and other products, the use of technology in the Viet Nam war, and fears about nuclear power among others. But all of them led to an atmosphere of mistrust regarding the objectives of technology development...[11]

Rather than learn these lessons, though, many large corporations, despite the entreaties of some who call for a renewal of purpose regarding basic manufacturing, continue to concentrate on the manipulation of capital.[12] In doing so, corporations preserve for themselves the illusion of innovation by calling such manipulations the rebirth of entrepreneurship. At present, corporations are striving to restore internal balance due to their legacy of failures and misplaced priorities. Furthermore, corporations are striving to ensure the public's confidence after repeated violations of public trust. And now the machinery of corporate consensus building cranks into higher gear and the rhetoric heats up.

Exacerbating this situation is the fact that large corporations are multinational made possible only because capital manipulation has been widely accepted by corporations throughout the world. The greater distance between corporations and the public, both geographically and politically, creates even greater opportunities for corporations to abuse the public trust. For example, some multinational corporations are busy selling off their structural assets in the United States to foreign producers. To worry over this, though, is to worry over the trajectory of the barndoor when your real interest lies in the escape route of the horse. For years now, American corporations have been, through American universities, selling off their intellectual assets -- the research findings of leading universities -- selling off these assets at wholesale prices. And to whom? First, of course, to competing multinational corporations. But second, to none other than the very Japanese corporations that are so often singled out as the fly-in-the-ointment of domestic progress and prosperity by the leaders of the very same corporations that have the audacity to preach competition and discipline to American school kids. While there has been much hand-wringing and tooth-gnashing over the predatory nature of Japanese business, and much alarm over cases involving the theft of intellectual property, the fact of the matter is that intellectual property is already commoditized and sold openly in an international marketplace. For example, over 50 Japanese corporations each pay about $50,000 per year for membership in MIT's Industrial Liaison Program (ILR). This membership includes "complete access to MIT resources," made especially convenient through MIT's office in Tokyo. Furthermore, note the fact that in 1987 46.6% of all U.S. patents were issued to foreign corporations. Almost one-fifth of the total went to the Japanese with Canon and Hitachi, both ILP members, receiving the lion's share.[13] This torrent of information flowing through the multinational corporate pipeline suggests that the lessons corporations urge on the schools -- competition, discipline, and accountability -- are really the ideological underpinnings of corporate consensus building.

The question now is, what form does corporate consensus building assume today? The current infatuation with technological literacy suggests an answer. I suggest that the rhetoric of international competition, which argues that the maintenance of the American lifestyle hinges on the intellectual accomplishments of its people is simply the ideological legitimation for an ongoing campaign of internal mobilization.

Just as the Cold War served as such an instrument for the past thirty years in both the Soviet Union and the United States, technological literacy is the new tune to which we must dance. Nationalism remains a fixed variable in the calculus of commodity production and consumption while the fear of foreign accomplishment displaces evil empires in the rhetoric of mobilization. I ask, is the current drive for technological literacy in some large part an attempt to plug the gap between corporate achievements to date and internal corporate imperatives? Is technological literacy the ideological basis of an old-fashioned Taylorist speed-up? In other words, do our intellectual processes currently receive unprecedented attention, and is intellectual work intensified and routinized precisely to even out the corporate balancing act? Is it a crisis of corporate development that compels today's infatuation with achievement? And to what extent does the technological literacy campaign provide corporations a vehicle with which to end-run our democratic institutions?

In sum, I argue that corporate rhetoric regarding education represents an ideological interpretation of current circumstances. This ideology: (1) obscures the role of corporations in the selection and development of technological innovations that favor narrow corporate interests; (2) obscures corporate failures by blaming public incompetence; and, (3) presumes that the American people must unquestioningly surrender their rights to determine the nature of work and the nature of schooling to meet the exigencies of internal corporate imperatives.

Conclusion

To conclude, I will return to my original concern with the education of computer teachers. If the role cast for educators by the corporations is realized, the focus of computer teacher preparation will become the apparatuses and techniques of educational processing in the service of corporate interests. Already throughout education, such phrases as "life-long learning" and "keeping pace with technology" are increasingly used by educational researchers and practitioners. Most teachers-in-training remain by-and-large unaware of the extent to which the current state of schooling is largely the result of past mandates for reform which emanate from business, industry, and the military: the same sources as today's drive to reform. Thus uninformed, teachers-in-training take for granted the distorted corporate vision of the nature and purpose of education.

Moreover, if the curriculum becomes narrowly specialized, focused on technology applications that suit corporate imperatives, we can anticipate an important outcome. Traditionally, people who succeed in school, succeed at work. To some extent, however, such successes have been stratified by race and class. Nevertheless, some members of American society, buoyed up by the high wages offered for low-skill industrial jobs, have slipped across the boundaries of race and class. Such slippage has contributed much to preserve meritocratic and democratic ideals. However, a corporatized, narrowly-focused curriculum will result in the intensification of income boundaries along the lines of educational achievement and permanently cut-off traditional routes of escape from poverty and disenfranchisement.[14] Questions we might face in the future include: Will the experiences of technologically literate people parallel those of industrial workers when the steel and auto giants collapsed and blocked an important channel of social mobility? What new job-training-programs might be offered in the future to those who are merely technologically literate?

We must develop new approaches to computer teacher education and technology education in general. A teacher training curriculum that includes social, political, and historical perspectives is an important step towards a wary and enlightened cadre of educators. With such a curriculum, while corporate leaders point the finger at school kids and proclaim that on their achievement rests the future of America, we might discover the extent to which these proclamations are disingenuous and the extent to which such proclamations shift attention away from the role of corporate interests in shaping our current circumstances. And with such insights, we might empower ourselves.

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SCIENCE LITERACY THROUGH APPRECIATION

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The Science literacy crisis in the United States has been documented beyond anyone's need to know. Jon Miller[1] in a recent American Scientist editorial summarized the situation concisely, culminating in a call for a national program to produce a scientifically literate generation by the year 2000. This is indeed a major challenge since in 1985 only 5% of the adult population qualified as scientifically literate according to Miller's criteria. Indeed, of those adults holding a Ph. D. degree, only 18% qualified! The pool of adults will not be improved by the current high school practice of avoiding algebra (45%), avoiding chemistry (70%), and avoiding physics (85%).

The long term solution involves the total educational loop - from elementary grade students (and teachers) to colleges' general education science requirements to teacher education programs. This represents an important generational challenge, and must be addressed by the widest possible segment of the education establishment. However, there are shorter term strategies that can be quite effective. Prior to presenting the philosophical approach and a specific strategy, some terminology needs to be clarified.

According to Webster, one who is literate is "educated, cultured; able to read and write, versed in literature or creative writing"; whereas one who appreciates is able "to grasp the nature, worth, quality, or significance of; to value or admire highly; to judge with a heightened perception or understanding: be fully aware of; to recognize with gratitude". The premise of this paper is that we must learn to appreciate science before we can hope to attain the lifetime goal of science literacy. In the short term, how can an appreciation for science be generated?

E. D. Hirsch, Jr.[2] in his controversial book "Cultural Literacy: What Every American Should Know", states the philosophy well.

> "To claim that the paramount goal of teaching basic science is to convey the scientific method is to make the same formalistic mistake as to claim that the main goal of reading instruction is to teach reading strategies. You cannot study "the scientific

> method" in the abstract; you can only study scientific methods in specific instances, and in order to understand those instances you need to know the scientific facts and concepts . . . the purely instrumental utility of scientific knowledge may be less important than the wider value to be gained from being acquainted with science as one of the great expressions of the human spirit. Science has been and continues to be one of the noblest achievements of mankind. From a humanistic point of view, its attainments are on a par with great achievements in art, literature, and political institutions, and in this perspective, science should come to be known for the same reasons as these other disciplines."

There are strategies that can be employed now to impart this appreciative attitude to a population that cannot become instant scientific literates by any definition, let alone the one posed by Hirsch in his list of 5000 "essential" names, phrases, and concepts. Within higher education, we must make use of the general education science course(s) to destroy the mythical scientific method that has eliminated the dynamic and inherent interest characteristic of real science. Unfortunately, at present, many institutions are reinforcing the misconceptions students arrive with, and thus assure a perpetuation of the science literacy crisis.

The strategy is simple: instil an appreciation (@ Webster) for science and allow people the rest of their lives to become truly literate - much as is done in other disciplines, including the arts. Why hasn't this occurred, if it's so simple? One obvious reason is that the strategy is easier to express than to accomplish. However there are other reasons that are forceful.

1. Tradition . . . "we have never done it that way!" Most faculty teaching introductory science courses to non-science majors simply present a watered-down version of the majors course, which often appears much like a rehash of a high school experience. We learned science that way . . . its THE way to learn science. Interestingly enough, how many of us did not really "appreciate" science until advanced courses?
2. An implicit assumption that the general audience cannot understand complex scientific concepts. Actually, I"ve come to think that this is a smoke screen for an inadequate pedagogy. Certainly if Richard Feynman could discuss quantum electrodynamic theory[3] before an educated "lay" audience, we should be able to discuss some basic science without all the mathematical trappings! We somehow believe that in our unprecedentedly complex culture, the average person cannot understand science: try following the analysis of a major sporting event; talk to someone under 25 about a technical

advance in which they are interested, be it computers, CDs, special effect movies, cars, video games . . . The key phrase is "in which they are interested" - most people are not interested in science topics, indeed, they avoid them. Since small children are just as curious as always about all facets of their environment, one must assume that in the teaching of science, we "turn off" most of the population. Not that we should hope to attract most of the populace into a scientific career, but the appreciation for science must not be lost, it must be nurtured.

3. Most science "breadth" courses are taught by faculty who have survived a process akin to natural selection, which nearly guarantees that their scientific mind has difficulty processing information in a way meaningful and interesting to a non-science mind, be it humanist, artist, or professional. This communication gap is often misinterpreted in terms already addressed in #2.
4. For a variety of reasons, non-mainstream approaches are a lot of work, and require an expenditure of creative energies that not only are not rewarded, but may actually generate difficulty with colleagues. However, it is interesting that a visit to your local bookstore will demonstrate that people are trying to circumvent the formal educational process by marketing paperbacks and inexpensive hardbacks for the public.[3-12] Therefore, the "difficulty" probably lies not so much with an absence of source material, as with an absence of the will or the absence of perceived need.

A specific strategy to address this problem is to integrate real science, real incidents, real people into existing courses, or to build a course based on the personalization of science. A course currently being constructed centers around scientific discoveries (titled Discovery: The Serendipitous Science). The major theme is that major scientific discoveries, while sometimes involving an element of luck or chance, are frequently serendipitous. Thus serendipitous discoveries are not a result of blind luck, nor are they the result directly from the experiments undertaken. Rather, a unique combination of circumstances arises that provides the opportunity for the idea or observation.

The unifying theme of serendipity allows the course to meet a variety of special interest on the part of the students. Currently, we cover examples from physics (waves, cosmology), chemistry (molecular structures, energetics, reaction mechanisms), and molecular biology.[5,13] We begin with an assault on students' misconceptions regarding the scientific method and the "doing" of science.[4,6] Along the way humanistic topics such as limitations of scientific models, sources of creativity, and seeing the impossible become possible, are discussed. The goal is to generate interest, by relating real science as done by real people to a broader context.

Typically, course texts would be Bohm,[4] Crick,[5] LeShan,[6] and Shapiro.[13] The first course assignment is a paper on the student's understanding of the scientific method, with a specific example provided from personal experience or the literature. The discussion in class focuses on the standard presentation of the scientific method and its application, followed by case histories of serendipity. Throughout the course, students are encouraged to seek out examples of serendipitous observations in the news and from current books available from standard bookstores and/or libraries.

The format of the course is lecture/discussion, with the unstated agenda to discuss the basic scientific principles needed to understand/appreciate the serendipitous observations. The basic scientific principles covered include physics, chemistry, and molecular biology. Obviously the level needs to be tailored to match the background of the students - thus the interactive format is essential so as to be aware of the knowledge level of the students and to make use of the better prepared students as peer mentors. Interestingly enough, a student serving as a peer mentor when discussing basic molecular principles may well be mentored by someone else when the discussion turns to the similarities in the creative processes of artist and scientists. The key is to relate the science as broadly as possible to the various major fields of interest represented by the class. The function of the instructor is to keep a reasonable focus on scientific principles, and point out how an appropriate understanding of lthe science illuminates the broader perspective.

The serendipitous examples chosen to fit the format described include Rœntgen's discovery of X-rays, the discovery of cosmic microwave background radiation by Penzias and Wilson, some examples from the instructors personal experience in chemical research, Fleming's discovery of penicillin, and Crick's discussion of the double helix, which leads nicely into a discussion of how scientists are/aren't provided with educational experiences designed to foster creativity.

Course assignments consist of short quizes designed to cover reading assignments and the basic science principles discussed in class. The major focus is on three papers, especially the final one which discusses a serendipitous observation not discussed in class or in the assigned reading, with the understanding that the scientific principles must be adequately explained. Again, the objective is to convince the student that the science is important and interesting, and that digging out an educated lay understanding of the scientific principles is not that difficult, given adequate motivation.

The net result of nonscience students experiencing such a course is that a reasonable fraction of the class finds the science avoidance behavioral pattern broken, or at least substantially reduced. Thus the road to science literacy is open to these individuals, utilizing the information readily available but assiduously avoided by most Americans.

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USING STS AS AN ADVANCE ORGANIZER IN PRE-SERVICE ELEMENTARY SCIENCE METHODS

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Pre-service elementary teachers often lack the confidence or competence to teach science effectively. For years they have been led to believe that science is represented by discrete disciplines, each with its own accumulation of facts and definitions. Somewhere along the way they have turned off their interest in learning science, and in most cases, they have met only the minimum requirements for graduation. This problem becomes all too real in elementary science methods classes when the pre-service teachers realize that they will soon be teaching science to dozens of curious little learners.

To help these individuals overcome their fear of science, the methods instructor must first help them to break down their misconceptions about science, particularly the content or disciplinary orientation which most of them perceive as a foreign language! The next step is to offer them a new structure for understanding science--much like they will have to do with children. Enter the "STS" approach! The STS approach provides a basic conceptual framework they can use to develop their own perception of science as well as that of their future students.

As a framework for understanding science, STS can be used as an "advance organizer" to make "science" more meaningful and more relevant to the needs of pre-service teachers. The main idea of an advance organizer is to provide a model of cognitive organization that is relatable to previously learned ideas and information and within which new facts, concepts and relationships can be incorporated. An organizer may be based on previous learning or experience, may use a clearly structured model or arrangement for new material, or it may be based upon a comparable structure of familiar origin. Regardless of the specific approach, an advance organizer should facilitate the learning of new information by linking it with cognitive structures or patterns already in place.

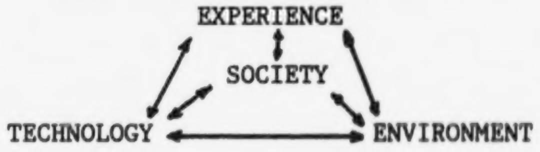
By expanding the concept of "science" to include other dimensions usually associated with STS, students can begin to see how science is much more than memorizing facts and principles. Even though "STS" may seem even more intimidating than just "science," many experiences that are perceived as being with science are actually with "technology." Likewise the "society" dimension should be relatively more familiar and therefore less threatening. If STS can provide this experiential and personal context for science, pre-service teachers will be better able to see the importance of science in their lives. As a result, they should develop a more accurate and integrated view of science and, as importantly, the social context of science.

The development of an STS way of thinking may also enable teacher and student alike to better understand the interdisciplinary nature of science and how it is related to other subjects. The central role of the individual and the interactive character of STS are further emphasized by and consistent with the hands-on method of teaching science that is so important in the elementary classroom.

THE STS METHOD

There is no single model for STS. In all cases however there exists at least the two additional dimensions of "technology" and "society" as well as the implied relationships between them. Central to the theme is the idea that all of the components must be considered as an integrated whole that more accurately reflects the nature of science in today's technological society. To consider science apart from this context severely inhibits any perception of science as a human enterprise and reduces the ability to understand or get involved in current issues.

The need for STS as a more accurate interpretation of what people need to know about "science" in today's society is well documented. "Technology" and "society" provide for a more tangible and more personal perspective, respectively, on the role of "science" in our lives. To complete the model, "environment," as a fourth perspective, can be added to provide the "place." Such a model offers a cognitive framework that individuals can use to organize the many different values and conflicts associated with problems like acid rain, deforestation, etc. The STS model can be illustrated with double arrows to denote the interrelationships between the various components:



This model can be presented to pre-service teachers at the beginning of an elementary science methods course to suggest to them that their perception of science is only a starting point. The other dimensions can then be described as the context for knowing science and understanding its importance in our society. Like a foreign language, knowing science without an opportunity to use it is meaningless. With this model as an advance organizer, all other science lessons can be structured similarly to reinforce the idea that science is much more meaningful when it is presented in a context that is identifiable.

OBJECTIVES & EVALUATION

Each of the four elements of the model may be further explained by suggesting objectives that indicate some of the relationships between these elements:

The Student Should Be Able To:

1. describe and discuss the scientific and technological nature of human society and our dependency on this system.

2. demonstrate an understanding of the complexity of environmental systems and a sensitivity to our dependency on the natural environment.

3. demonstrate an awareness of the potentials and constraints that define the limits of the role of technology in solving problems faced by today's society.

4. display optimism and skill in identifying, evaluating, and applying relevant information in a problem solving or decision making situation involving the role of technology in society.

There are many more objectives that could be used to show relationships within the model, and individual lessons would require objectives of much greater specificity. The important thing to remember is that each successive presentation to the students be clearly structured to fit their expanding conceptual framework.

Evaluating students' understanding of the STS approach can be accomplished several ways. One method is to have them illustrate their own model of how STS can be incorporated into a particular topic area within the elementary science curriculum. Everyone will develop a model as they perceive it, but there should be some common elements. A similar method would be to have the pre-service teachers work through a simulation exercise about a particular science concept--and its context--and at some later time have them produce a concept map of the essential ideas.

More traditionally, exam questions may be designed to measure how well the objectives were achieved. For example, "Choose an issue (list provided) and describe how it is related to science, to technology, to the environment, and to society. Also, suggest a realistic decision making scenario about the issue that would be appropriate for use in a 4th or 5th grade classroom."

SUMMARY

Project Synthesis calls for several student outcomes within the "societal issues" goal cluster. Therefore, we need to implement more of an STS emphasis in pre-service elementary science methods courses.Successful reform of science education will require a consistent and unified effort at all levels, but the elementary level may be the most critical.

The use of an STS advance organizer to present science to pre-service elementary teachers can have many important benefits. First, the future elementary teachers need to have solid conceptual structures regarding the nature of STS if they are to present it to others. Structuring "science" instruction as "STS" is already new to them--presenting it in an organized fashion is essential. Secondly, almost everything learned in the elementary years becomes an "advance organizer" for the students. If the teachers can gain new insights about the learning process through the use of advance organizers, they will be more effective teachers. Third and no less important, the content of STS itself represents the urgency with which we must make an organized and unified effort to give everyone the knowledge and skills to adapt to a changing world.

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Integration of Technology Assessment into a General Education Environmental Studies Course

by

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INTEGRATION OF TECHNOLOGY ASSESSMENT INTO A GENERAL EDUCATION ENVIRONMENTAL STUDIES COURSE

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Abstract

Environmental Studies is a logical home for the teaching of technological literacy. Environmental issues with a technological component include energy, pollution control, pesticide usage, treatment of drinking water, etc. Also, introductory Environmental Studies courses are often a very pragmatic instrument for teaching technology related issues since the syllabi are often more flexible and expansive than corresponding courses in the traditional natural sciences -- chemistry, biology and geology. At William Paterson College, the inclusion of technological issues, such as those above, has been a standard part of our introductory General Education course in Environmental Studies since 1979. Additionally, each semester some topical issue such as the Ozone Hole or radon in the home is highlighted. The course includes an environmental economics component where the concepts of externalities, cost-benefit analysis and economic growth vs. steady state economics are stressed. All these topics clearly have a strong technological component.

In our course these technological issues are often approached from the integrating perspectives of Bent's Theorem (processes which minimize entropy production within the biosphere are best) and Ockham's Razor (simple solutions are most often the best solutions and should be tried first). Application of these assessment principles are discussed for four technologies -- home heating systems, agriculture, flood control, and computation of simple arithmetic problems.

Introduction

Environmental Studies has long been a natural habitat for technological literacy. Environmental issues with important technological components include energy, pollution control, pesticide usage, treatment of drinking water, transportation, food and agriculture, solid and chemical waste disposal, flood control, food additives, birth control, sewage disposal, etc. In fact, it seems difficult to find an environmental issue which does not have a significant technological component.

Also, introductory Environmental Studies courses are often an extremely pragmatic instrument for teaching technology related issues since the syllabi are usually more flexible and expansive than corresponding courses in the traditional natural sciences of chemistry, physics, biology and geology. In the environmental field, the broader societal and even the biospherical effects of human actions are a part of the standard paradigm of the discipline, again in marked contrast to the traditional natural sciences. Environmental Studies has traditionally considered technological issues in terms of concepts such as soft vs. hard technology and appropriate technology.

At William Paterson College, the inclusion of technological issues, such as those above, has been a standard part of our introductory General Education course in Environmental Studies since 1979. Additionally, each semester some topical issue is highlighted. Recent issues include Nuclear Winter, ocean dumping, the Ozone Hole, radon in the home, and resource recovery facilities (incinerators) . The course includes an environmental economics component where the concepts of externalities, cost-benefit analysis, and economic growth vs. steady state economics are stressed. All these topics clearly have a strong technological component.

Technology assessment is a very difficult field of study. Traditionally one can use simple basic economic principles such as when a consumer tries to maximize the derived quantity internal benefits/internal cost. Here only the dividend can usually be measured with any degree of certainty and the divisor is a complex and ill defined function of such variables as quality, longevity, safety, and aesthetics. Also, the weighting of these variables is extremely individualized. One need only look at the purchase of an automobile to understand the variability of the basic components of the equation. Even an informed consumer, such as one who is a chronic reader of *Consumer Reports,* will be continually frustrated by the paucity of hard data and avalanche of soft data (i.e., advertising) which makes such consumer decision making highly imperfect. And yet, this is a simple exercise compared to the complexity of measuring the total benefits vs. total costs explicit in Cost-Benefit Analysis or Risk Assessment where externalities (societal and environmental costs and benefits) are often difficult to even *identify,* let alone *quantify*, as either some monetary amount or a probability as required by each methodology, respectively.

In our course we attempt to look at Science, Technology and Society (STS) issues from an assessment perspective where two general principles are used as the primary assessment tools. These two principles are:

1) **Ockham's Razor** (or the Principle of Parsimony) - Simple solutions are usually the best solutions and should be tried first (Adams 1987, Boehner 1957, Searle 1948).

2) **Bent's Theorem** - Processes which minimize entropy production within the biosphere are best (Bent 1971, 1977).

Both statements have been rephrased by me. Both concepts have been explored extensively, both explicitly (Bent, Georescu-Roegen, APS, Rifkin, Lepkowski, and Schumacher) and implicitly (Thoreau, Leopold, Odum, Commoner, Lovins, Miller, Kraushaar and Ristinen, and Enger *et al.*). It should also be stressed that these two principles are *not* mutually exclusive and, in some cases, may be virtually mutually inclusive. Additionally, the two principles may be applied qualitatively which makes their application extremely palatable to many nonscience students unlike Cost-Benefit Analysis and Risk Assessment. While measuring entropy directly in complicated processes is highly problematic, it can be stated that processes which involve the burning of nonrenewable fossil fuels and distribute pollutants widely (maximum dilution of pollutants) are processes which greatly increase the entropy of the environment. Indeed, the magnitude of the entropy production can be approximated by considering entropy as a measure of spontaneity or nonreversibility. Thus, the easier a process is to do, and the more difficult to undo, the greater is the increase in entropy (Mandeville 1979). Both the burning of fossil fuels and dilution of pollution are clearly difficult processes to undo and therefore are processes involving large increases in entropy. Also, Bent's Theorem is a wonderful way of making the Second Law of Thermodynamics more meaningful in a nontrivial manner. It should also be understood that these are guiding principles in technology assessment and should not be considered dogmatically or independently of other assessment criteria.

Case Studies

Application of these two principles will be used to examine four technological/environmental issues: 1) Alternative means of heating a house, 2) Assessment of agricultural 'efficiency', 3) Flood control and 4) Solving 'simple' mathematics problems. These four issues are considered because they involve a large range of topics, they have a high degree of interest and/or importance (at least locally), and they nicely illustrate application of our two fundamental assessment tools.

Table 1 is a list of advantages and disadvantages of three alternatives for heating a home: 1) conventional oil furnace, 2) hydroelectric-electrical heating (using hydro power to generate electricity, and 3) solar power. Application of Ockham's Razor and Bent's Theorem suggests that solar power is the most appropriate technology here since it seems the simplest system, is small in scale, utilizes a perpetual resource (sunlight), and has minimum negative environmental degradation associated with its use. These are all attributes of a process where entropy production within the biosphere is minimal. This 'soft' technology is in direct contrast with the 'hard' technologies of large scale hydroelectric power production and the complicated infrastructure associated with the production, distribution and use of petroleum. This is not to say that solar power does not have significant disadvantages (Inhaber 1982), yet, in this case, application of our two main principles seems to intuitively give the 'best, most environmentally sound' answer. It may also be the most economically sound technology from the consumer's perspective.

As a postscript to this analysis, I suggest to my students that an alternative integrated approach to home heating may be best. This technology involves the use of solar heating in an underground house using anaerobic digesters as a back-up and supplemental source of energy for cooking and perhaps for generating electricity. Underground or earth sheltered houses are estimated to save 25-75% of heating, cooling, and maintenance costs, and with new building materials are comparable in costs to conventional buildings. They also provide more privacy, are quieter, and more secure than conventional houses (Miller 1988). Of course, there are significant disadvantages of underground houses, in terms of aesthetics, flooding, and now perhaps from increased radon concentrations in certain geographic areas.

Anaerobic digesters (or biogas generators) at first perusal appear to be an extremely attractive alternative method for providing home energy by using home wastes (household garbage and sewage, lawn clippings, fallen leaves, etc.) to biologically generate methane, the major component of natural gas. This fuel would be 'free' and would proverbially kill three birds with one stone since the process simultaneously produces energy from a renewable resource, reduces the solid waste problem, and reduces the need for sewage treatment. The process is well developed and is estimated to account for about 50% of the energy budget in rural China. Other advantages and disadvantages of the system are given in Table 2. The advantages *vis-à-vis* the disadvantages of the technology seem to be overwhelming. Certainly, in terms of Bent's Theorem, the process seems to be extremely attractive. Yet, clearly our culture is not inundated with such systems. Why? The answer seems to lie with Ockham's Razor. While such systems are intrinsically simple in concept (the process occurs naturally in marshes, bogs, and landfills for instance), in reality the control of such systems is very difficult to achieve because of contamination by metals and variability in temperature, raw materials, pH, etc. Also, the Chinese systems are very labor intensive. The process in reality is not simple. Ockham's Razor has cut open and exposed a near fatal flaw. Indeed, in China and India, use of such facilities is declining (Miller 1988).

American politicians love to point to the unrivalled productivity of American agriculture as a prime example of American individualism, ingenuity, and the work ethic. It may very well be all of these, but is it a model technology to be exported to all other parts of the world, particularly to the less developed countries? The answer appears to be no. As Table 3 indicates, American agricultural productivity, as measured in terms of the energy of the output (food) divided by the cultural energy subsidies (total energy input - solar energy input), is extremely inefficient when compared with simple horticulture. The vaunted American agricultural efficiency is highly efficient only in terms of food energy output/*direct human* energy input. As Howard Odum (1971) has indicated, Americans really eat oil and not potatoes. The heavy use of fossil fuels and other basically renewable resources for mechanization (both in production and actual use), application of fertilizers and pesticides, irrigation, etc., have a corollary in increased pollution, soil erosion, and eutrophication which can be expressed in terms of having very high entropy production. Also, these hard technologies are obviously not simple. Here application of Ockham's Razor and Bent's Theorem may suggest that instead of exporting American agricultural technology to the Third World, we should consider the reverse.

In northern New Jersey, flooding is a chronic problem primarily because of the high population density and resulting economic considerations which drive the construction of houses into the floodplain. In the Passaic River Valley, there have been over thirty different flood control studies, some predating the American Revolution. None has ever been implemented. The last plan proposed by the U.S. Army Corps of Engineers was to build two huge tunnels (each 9 or 10 m in diameter) from areas where flooding is most common, to near the mouth of the river. The cost of this diversion system in 1981 was estimated as $1.9 billion. Typically, upstream communities support the plan while the downstream communities, at and below the proposed outflow point, oppose the plan. This lack of a supportive consensus will almost certainly mean the plan will not be implemented since typically Congress will not support major public works bills unless the affected state's congressional delegation show unanimous support. This is not forthcoming.

An alternative plan suggested by some New Jersey state legislators and supported by several environmental groups is to use several reservoirs in the watershed as retention basins in times of imminent flooding. Historical records indicate that no major flooding has occurred in modern times except when these reservoirs are at or near capacity. This appears to be a solution compatible with Ockham and Bent. It certainly is a technologically simple solution which appears to have little of the entropy problems implicit in the hard technology tunnel system proposed by the Corps. Unfortunately, it is not a simple *political* solution when one considers that the affected water companies are all quasi-governmental agencies which typically seem to combine the worst features of both the public and private sector -- little public accountability and an entrenched myopic bureaucracy resistant to change. Their mandate is to provide drinking water, not flood control. Certainly, the two objectives are basically incompatible since one seeks to maximize the amount of water in the reservoirs, while the other seeks to minimize the water. Technologically a compromise seems feasible, politically almost certainly not.

Sociologists and anthropologists tell use that we have moved past the Industrial Revolution to a Post-industrial or Communication Era whose central icon is the computer. The analogy in Table 4 strongly suggests the persuasive chief attribute of computers. Their remarkable ability to process information quickly, accurately, and rather cheaply, both economically and energetically, is accepted uncritically in our society. Table 5 gives the results of a simple experiment comparing three technologies for doing rather elementary arithmetic. The technologies were 1) pencil, 2) solar calculator, and 3) microcomputer. The results in terms of time, effectiveness (grade), and perhaps in terms of consumer economics and environmental degradation as well, suggest that the solar calculator is the most appropriate technology for such operations. In terms of training time, the calculator also seems best. Training for the manual calculations literally requires years (at least in our educational environment), while the computer requires weeks or months, but the calculator only requires minutes. In terms of both Ockham and Bent, the calculator appears to be an intermediate between the alternatives. Pencils are a simpler and softer technology; computers are more complicated and harder. Yet, in many respects the calculator technology seems closer to the computer than the pencil, except, most notably, in terms of cost. Basically a computer is a more flexible and powerful calculator and clearly using a computer to add 6 + 8 is as inappropriate as using a chain saw to cut butter, that is, it is a technological overkill. Here the simplest, least environmentally degrading technology (presumably the pencil) may not be the most appropriate technology.

Perhaps our elementary school students should be learning calculator literacy as opposed to basic math facts and computer literacy. Indeed, there may be some movement toward 'calculator literacy' at the elementary level (McCallum 1989).

Yet this paper was obviously prepared by the use of a microcomputer. The attraction of modern computers may be that, paradoxically, they are extremely complicated technologies which are being developed to ensure that their use is as simple as possible and to simplify other technologies as well. This is the quintessence of the 'user friendly' concept. Others technologies attempt to perform the same simplifying function, but their success in achieving this objective appear less compelling.

Conclusion

Ockham's Razor and Bent's Theorem are two valuable, but not infallible, evaluation criteria which can be used to assess various alternative technological courses of action. They are rather simple qualitative concepts which can be easily applied at the nonscience undergraduate level. The irony that this hypothesis would presumably find great favor with William of Ockham has not escaped the author's attention.

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Table 1. Comparison of Three Systems for Home Heating (after Miller 1988)

Conventional Oil Furnace

Advantages:

1. Old, well developed technology
2. Fairly reliable and safe
3. Lifetime of system relatively high (~20 years)
4. Maintenance costs usually low

Disadvantages:

1. Furnaces are expensive (>$2000)
2. Fuel costs are moderately high
3. Oil is a nonrenewable resource. Domestic supplies are being rapidly diminished
4. Pollution from use is moderate
5. Low efficiency (12 % overall)
6. High entropy production
7. Hard technology

Table 1. (cont.) Comparison of Three Systems for Home Heating (after Miller 1988)

Hydroelectric - Electrical

Advantages:

1. 'Fuel' (falling water) is free
2. 'Fuel' (falling water) is renewable
3. Very low pollution associated with use
4. Very high efficiency (82 % with conventional resistance heater (~160 % with heat pump)
5. Old, very highly developed, fairly safe technology (at least for the consumer)
6. Costs to consumer low, in theory; maintenance costs also low
7. Long lifetime of system (some hydroelectric turbines 75 years old are still in operation)
8. Entropy production with use is moderately low

Disadvantages:

1. Availability depends strongly on geographic location
2. Estimated 50 % of domestic supply already tapped. Use of remaining 50% will entail construction of dams
3. Costs to consumer high in practice
4. Capital costs very high
5. Construction of hydroelectric facilities (and particularly dams) is dangerous
6. Entropy production and pollution associated with construction is very high
7. Hard technology

Table 1. (cont.) Comparison of Three Systems for Home Heating (after Miller 1988)

Solar Collectors

Advantages:

1. 'Fuel' (sunlight) is essentially renewable
2. 'Fuel' (sunlight) is free
3. Low pollution (virtually none associated with use)
4. Technology relatively simple and safe
5. Entropy production is low
6. Semisoft technology

Disadvantages:

1. 'Fuel' (sunlight) supply is periodic (no good at night), and variable (considerably diminished during cloudy weather). Also, the least is available when it is needed the most (winter); depends a great deal on climate (excellent in Arizona, bad in Washington State)
2. In Northern climates, backup system (conventional furnace, wood stove) is often needed
3. Technology is new and not highly developed
4. Capital costs are moderately high (>$2000). Maintenance costs should be low but are relatively unknown in actuality
5. System lifetime should be high, but still relatively unknown in practice

Note: Efficiency is moderately low but is mitigated by the fact that the 'fuel' (sunlight) is free!

Table 2. The Advantages and Disadvantages of Anaerobic (Methane or Biogas) Digesters (from Miller 1988 and Enger *et al.* 1986).

Advantages:

1. Uses food wastes, human wastes (sewage), grass clippings, leaves, and agricultural wastes as fuel thus obtaining energy from renewable resource while decreasing disposal problems of these items
2. Fuel is free
3. Technology is well developed (in China and India)
4. Natural gas appliances and delivery system already in place in many homes and excess methane may be used to run these appliances
5. Efficiency is moderately high (30-60%)
6. Residue may be used as fertilizer
7. Systems can be designed at the block or community level and are particularly useful in rural areas where agricultural wastes can be used as the major component of the fuel mix

Disadvantages:

1. Technology not highly developed in U.S.
2. Capital costs almost certainly high
3. Chinese and Indian systems are highly labor intensive
4. Biological process is slow and difficult to control precisely
5. System efficiency is significantly reduced when fuel mix is altered or from changes in temperature, pH, or contaminated with detergents or heavy metal pollutants (therefore cannot be used with industrial wastes as fuels)
6. Capital costs high presently (particularly if highly automated)
7. Fuel value of product about 60% of natural gas
8. Product includes significant amounts of carbon monoxide (CO) which is dangerous
9. Smelly (in practice)
10. Lifetime and safety of systems is uncertain

Table 3. Agricultural Efficiency (from Steinhart and Steinhart 1982)

System	Energy Efficiency[a]
Wet Rice Culture (Indonesia)	40
Hunting-gathering	10
Intensive Rice	5
Range-fed beef	2
American agriculture (1910)	1.1
Offshore fishing	1.0
American milk (grass fed cows)	1.0
American eggs	0.4
American agriculture (1940)	0.25
Intensive aquaculture (fish)	0.15
American agriculture (1970)	0.12
Feedlot beef	0.07
Open ocean fishing	0.07

[a] ΔE output of food/ΔE cultural input (total energy - solar energy). ΔE cultural input includes contributions from machinery, human and animal labor, irrigation, fertilizers, pesticides, etc. at the agricultural site. This does not include energy contributions for post-farm food processing, storage, and transportation. These contributions may be three times greater than on-farm values used here.

Table 4. A Transportation vs. Computer Analogy

Transportation

Method	Walking	Airplane (SST)	Ratio
Speed (mph)	4	1600	400
Development time (years)	2,000,000?	70	-
Cost	-	$200 million	
Distance/Energy (mile/MJ)	5	.037[a]	0.0074

Information Processing

Method	Human Brain	Supercomputer	Ratio
Rate[b]	40	$4x10^{11}$	10^{10}
Development time (years)	2,000,000?	40	-
Cost	-	$6 million	-
Operations/Energy (per J)	0.4	$3.2x10^{9}$[c]	$8x10^{9}$

[a] Assuming 50% capacity and fuel usage 2 x normal jet.

[b] Logical operations/second

[c] Assuming power requirements comparable to main frame

Table 5. A Comparison of Three Technologies for Performing Elementary Mathematical Operations[a]

	Individual technologist[b]			
Technology	A	I	N	Mean
Pencil				
Time (min)[c]	11.70[d]	4.45	9.58	8.58
# Correct (Maximum 10)	9[d]	9[e]	5[e]	7.7
Energy subsidy	0	0	0	0
Cost ($)				0.05
Solar Calculator (with square root)				
Time (min)	1.80	2.01	2.32	2.05
# Correct (Maximum 10)	10	10	8[f]	9.3
Energy subsidy	0	0	0	0
Cost ($)				9.95
Microcomputer (Macintosh Plus)				
Time (min)	9.95[g]	6.58	13.36[h]	10.05
# Correct (Maximum 10)[i]	10	9	7	8.7
Energy subsidy (kJ)[j]	48.9	32.2	66.7	49.3
Cost ($)				2200

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[a] Problems were:

1) 6 + 8 = 14
2) 635 + 179 + 506 = 1320
3) 17 - 9 = 8
4) 6342 - 1789 = 4553
5) 7 x 6 = 42
6) 738 x 29 = 21402
7) 56 ÷ 8 = 7
8) 761 ÷ 4 = 19.05
9) $\sqrt{763} = 27.622454$
10) (68 + 99 - 42) x 6 ÷ 3 = 250

[b] A = Advanced, I = Intermediate, N = Novice programmers.

Table 5. (cont.) A Comparison of Three Technologies for Performing Elementary Mathematical Operations

[c] Times do not include 'start-up' times (finding and sharpening pencil, finding calculator, finding correct computer disks, etc.) Only A checked his work. This time is included in his totals.

[d] Square root (Problem 9) was calculated correctly to three significant figures; 6.23 minutes used in this single calculation.

[e] I and N did not attempt to solve the square root problem.

[f] N 'forgot' to do one problem; for Problem 9 entered wrong number.

[g] A's program was 'user friendly' (printed out problem as well as answer); I and N's programs only printed out answer.

[h] N began by writing 10 individual programs, one for each problem; after 5.06 minutes began to write one program.

[i] Both I and N missed Problem 9 since neither knew the BASIC command for square root.

[j] Including computer, printer and external disk drive.

Teaching "Lead in the Environment"

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Abstract

Due to the wealth of data available on the problems created by lead in the environment, this topic is used as a focal point in the last quarter of the two semester course entitled "Scientific and Technological Literacy: The Environment". Classes meet for two lecture hours and one two hour laboratory period every week. The earlier part of the course covers basic scientific and technological themes in the environment while this latter part applies newly learned student skills to a particular issue. The study of lead serves as a model for the investigation of other environmental problems.

TEACHING "LEAD IN THE ENVIRONMENT"

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Introduction

The problem of lead in the environment is studied in detail as part of a modular course entitled "Assessing the Environmental Future". The core curriculum at Iona College includes a six credit requirement in Science and Technology. Students taking the Scientific and Technological Literacy (STL) courses as part of the core choose a sequence of four modules from the themes of health, energy, or environment. Each module is a 1.5 credit course taught for half a semester; there are two one hour classes and a two hour laboratory each week. The first three modules in a theme emphasize skills, tools, and model building. The fourth level module emphasizes assessment and decision making.[1]

In the fourth level module for the environmental theme, the topic of lead in the environment is the example chosen to illustrate environmental decision making processes. The lead problem is a useful model because much data exist and a number of regulatory actions regarding its use have already been taken by the Federal Government. After gaining experience through their study of what can be done with one type of environmental pollutant (lead), groups of students study other environmental problems and present their findings to the class at the end of the term.

The Course

a. Classroom Sessions

The STL faculty developed three booklets for use in the module: a student manual which contains class outlines and laboratory worksheets, a text which contains chapters on lead, probability, and decision making schemes, and a reader which contains articles from newspapers and magazines.

The first week develops the concept of making an environmental decision based on probability. The decisions made on environmental issues, such as how much lead in the atmosphere will adversely affect humans or what is the safe level of an impurity in the water supply, are based on probabilities. A computer experiment based on a dice game is conducted during the laboratory session and the students collect data from playing the game several times. The person playing the game has to roll two dice and wins when two sixes appear. The person is able to roll the dice a number of times. The problem which the students solve is to determine, by an experiment on the computer, the number of times that the dice have to be rolled in order to win a fixed percentage of games.

Several concepts are able to be learned from this exercise. The first is that the obvious answer for fifty percent success rate (eighteen throws) is not the answer at all. Since the probability for success as a function of the number of rolls cannot be easily determined from the students' limited knowledge of probability theory, they must run an organized experiment to obtain a reasonable answer. After they determine their number for a fifty percent success rate, they find out that different experimenters come up with different answers most of which are clustered.

The more trials they make, the tighter the cluster becomes. A spreadsheet is used to record and graph the data and the decision is made by interpreting the graph.

Having improved on their concepts for decision making based on probabilistic occurrences, these concepts are used to develop methods that are used in environmental areas. The nine step approach used by the Committee on Lead in the Environment[2] serves as an outline to indicate the types of information needed to make decisions. The decision making model begins by collecting necessary information to do the study. The first three steps identify the sources of lead and the pathways of environmental transfer, the human populations exposed to lead, and the level at which these populations are exposed. Since most of the students live in urban environments, they realize that the air they breathe and the water they drink are two pathways for environmental transfer and that they are part of a population exposed to lead. Since many students live in dwellings with lead pipes and solder joints, another application is the decision which should be made regarding lead plumbing.

The next three steps in the model involve determining quantitative relationships based on information which is incomplete. This involves determining the relationship between environmental exposure level and the level of lead in the body, determining the connection between the level of lead in the body and the associated biological change, and finally establishing what a "safe" level of biological change is. Some experimental information exists to make these decision, but the information is scattered. The information is costly to obtain; for instance, the relationship between exposure level and the level of lead in the body cannot readily be determined in a laboratory. Investigators must obtain evidence after the fact. For instance, a relationship between the amount of lead in the air and the level of lead in the blood has been determined,[3] but this was obtained after people had already been exposed to high concentrations of lead in the atmosphere. Likewise, the detrimental effects were determined only after people had been adversely affected by lead contamination. The classroom discussions touch upon the economic problems involved with obtaining the data and the ethical issues of both the experimentation and the environmental problem.

The final three steps in the decision making process are to develop possible strategies to improve the environmental situation, to apply cost and risk benefit analysis to these strategies, and finally, to implement a decision with a built in evaluation mechanism. One decision which has been taken is to remove lead from paints produced within the United States. This has drastically reduced the amount of lead poisoning among children who are of teething age; recent incidents have shown that products with lead based paint can still be imported into the United States. The cost and risk benefit analysis is a business oriented approach; this appeals to the business students who are able to apply their own decision making skills.

b. Laboratory Sessions

A two hour laboratory session is held each week. A set of laboratory experiments are conducted which develop methods for identifying the presence of lead. In addition to being techniques that are used to determine the presence of lead, the experiments are used to teach principles of science.

The first experiment is a qualitative analysis of several metals including lead. This analysis is based on standard chemical methods. Students then do a quantitative analysis to determine the concentration of lead in a solution. Though many analyze the same solution their answers vary; usually they are clustered around some average. With concentrations constantly being cited in the literature, working with concentrations gives better insights into the articles they are reading.

The first method for performing a quantitative analysis is to obtain a precipitate and eventually weigh it. The precipitate is clearly visible with concentrations of the order of one part in a thousand. As the solution is diluted, the precipitate is not as obvious. By constantly diluting the solutions, the student determines a minimum level of detectability using this analysis. The minimum concentration for detecting lead using this method is fifty parts per million; this level is a thousand times more concentrated than the Federal Standards for lead in water. Students realize that their experimental techniques which yield a "visual" presence of lead are not precise enough. Some other method is needed.

At this point in the course, concepts of absorption of light by atoms are introduced. Atomic energy levels had been taught in the first level module. An application of this model is used to detect small concentrations of lead. An atomic absorption apparatus with a lead lamp is located in the laboratory; a laboratory session is spent on the theory of atomic absorption and the working of the apparatus. During this time, the students learn how to calibrate the device and make some test samples to check their technique. Using the apparatus, they determine the amount of lead in different liquids that have been stored in a lead container for a week. The following week, they bring in water samples from home; also, during the lab period, students take water samples from the buildings on campus. The device can detect lead to a level of one part per million; during this lab, there are usually several samples which register readings.

For the future, an electro-chemical experiment is planned which can measure concentrations to one part per billion. The new apparatus would have the sensitivity to measure lead concentrations in water at a level less than the Federal Guidelines for clean water. The STL lab can then be used as a center to test local water supplies with undergraduate students involved in the testing.

Applications

Having studied lead in the environment, the student groups have a basis to look for information on other environmental issues. Over the years, groups have chosen topics such as noise pollution, use of aerosols, sulfur fuels, and phosphate detergents. These are problems which they all face. In preparing a class presentation, they learn the scientific aspects of the issues, the technologies involved, and different strategies to improve the environment.

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Technology Bound

"Technology Bound", a six-session series of skills and confidence building activities for high school aged females and their guidance counselors, was funded through the Sex Equity portion of the Carl D. Perkins Vocational Education Act.

Each week participants were provided with a hands-on laboratory type experience designed to acquaint them with information and procedures on a designated science/technology topic. The purpose of the activity was to provide experiences beyond those that a typical high school class engages in which will build confidence in the participants ability to successfully achieve skills and knowledge in science/technology areas. The participants, both students and counselors, were exposed to terminology, skills, and processes specific to the chosen technological area. The experiences were "hands-on" and interactive. After mastering basic skills and content the participants were presented with a "work" situation. They were encouraged to use problem-solving methodology to accomplish the job-related task. Less supervision was provided as the students increased their problem-solving capabilities through the six sessions.

Guidance counselors, participating in the same experiences as the students gained a better understanding of the skills, equipment and terminology employed in the career areas addressed. Weekly topics were Water Quality, Electronics, Atmospheric Sciences, Computer Automated Drafting, and Microbiology (2 sessions).

The major activities for the Community College of the Finger Lakes "Technology Bound" program were accomplished from August 1988 through November 1988. Evaluation of some outcomes of the program will not be completed for a number of years.

Early in August 1988 letters were sent to principals and guidance counselors at area high schools. Follow-up telephone calls provided information and encouragement. The schools were invited to send up to five students and one or more guidance counselors to the "Technology Bound" program. Sophomore and junior female students were selected by the schools. It was suggested that the students chosen be underachievers in math and/or science. The student commitment was for six weeks. Guidance counselors provided transportation from the home school to CCFL and back. The school could rotate guidance counselors through the six week commitment. Stipends were paid to the guidance counselors to cover transportation costs.

Guidance counselors and students were sent letters explaining the "Technology Bound" program and providing information on time commitment and location.

Equipment for the hands-on experiences was provided by the Community College of the Finger Lakes and the Atmospheric Sciences Research Center. The procedures that were followed for each experience were recorded. Photographs and video recordings of the activities were taken.

The six-week agenda was established after group planning sessions and individual input from the prospective instructors and the counseling staff at CCFL. Speakers who could relate the technology activities to the work place and job opportunities were gleaned from industry and educational institutions.

Each weekly session started with refreshments and informal interaction from 3:30-4:00 p.m. The technology topic was presented from 4:00-6:00 p.m. The presentation began with an introductory information dissemination period followed by the hands-on experience. All sessions emphasized problem-solving activities. For each session there was a primary instructor and a back-up professional, so that along with the director and program technical aide, there were two content specialists available to instruct the students and counselors.

Dinner started at 6:15 p.m. followed by the evening's guest speaker. Sessions generally ended at 7:30 p.m. Speakers were contacted by phone to verify their commitment and arrange for equipment needs.

The "Technology Bound" program encompassed 21 students and 10 guidance counselors from six high schools. One student dropped out of the program. Student attendance was good, with only one or two students absent any week. Fourteen out of 21 students attended all sessions.

Analysis of evaluations filled out by students indicates that after completing the "Technology Bound" program they are more aware of career opportunities in science and technology. The "Technology Bound" program provided information and experiences in non-traditional employment fields for the female students and the guidance counselors.

The "Technology Bound" program involved cooperative experiences between local and regional businesses and educational institutions. It also emphasized existing relationships and encouraged new communications between CCFL and local high schools.

Overall, evaluations of the "Technology Bound" program indicate that both segments of participants were extremely satisfied with the program and that they would recommend attendance to their respective peers.

ORIGINAL

THE ROLE OF MASS COMMUNICATIONS IN ECONOMIC AND EDUCATIONAL EXCHANGE IN THE CARIBBEAN

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The Role of Mass Communications in Economic and Educational Exchange in the Caribbean

Introduction

The lack of long-range planning in educational technology ,in specific, and in mass communications, in general, makes Caribbean economic competitiveness in a global village impossible. An inappropriate 1979 challenge to Caribbean countries was to acquire technology as the means of economic and educational progress. An appropriate challenge in 1989 is for Caribbean countries to acquire a sociotechnical system of manufacture and a sociotechnical system of use. The latter challenge recognizes a strategic plan to integrate science, technology and society.

In using Stephen Kline's definition of a sociotechnical system of manufacture, Caribbean countries concentrate on the elements to manufacture hardware: people; machinery; resources; and environment. This system encourages regional development rather than dependence. Caribbean countries, using Kline's definition of a sociotechnical system of use, concentrate on effective and efficient combinations of hardware and people (Kline, 1986). This system recognizes the need to train, as well as to retrain. a diverse work force to operate within a technologically oriented world. It is a macro rather than micro approach to technological literacy with the focus on the development of human resources,

Foreign Influences on Mass Communications in the Caribbean

Technological literacy is important for all segments of society in a global village. The negative influences of an elite group within developing countries and of a foreign culture on Caribbean development are disturbing. There is a widening communication effects gap within nations as well as between nations. Rogers (1974) postulated that elites employ communications, including educational broadcasting, to enhance their own position rather than to advance the remainder of the population. Through educational, technical, economic or political status, elites often implement and continue to support foreign media programs.

Additionally, Caribbean countries have a disproportionate number of nonelites who are susceptible to particular messages within Western media programs. Imported radio and television programs introduce and subtly support a foreign culture in conflict with regional development, economic independence and previous attitudes, beliefs and values. For example, Hamelink (1983) established the link between the standardization of tastes, values and attitudes by American advertisers and the spiraling importation of goods in developing countries. Jenkins (1988) found further evidence of this significant influence through investigating the role of advertising as a percentage pf gross national product finding it as high in Jamaica as in the United Kingdom.

With the proliferation of televisions and satellite dish receivers, CNN (Cable News Network) has surpassed the BBC (British Broadcasting Corporation) in foreign news and entertainment. In some Caribbean countries, local programming is restricted to the domestic news. Western countries continue to dominate control of instructional media because the United States and the United Kingdom develop most of the programs and train most of the staff who are affiliated with the programs internationally. Cultural ideologies appear in program content, planning and design. Officials of developing countries charge that cultural imperialism is embedded in a spectrum of programs. However, the relative ease of the importation of programs is disproportionate to the difficulty of the production of domestic or regional programs.

Constructive Uses of Educational Technology in the Caribbean

The objectives and content of media programs which are developed to meet the needs of Caribbean countries should be adapted to the culture and background of the target population. Blanket applications of educational technology too often ignore this tenet. Differences in learning styles and previous instructional experiences are disregarded. For example, research demonstrated that when technology only reinforced formal lessons in developing countries, there was not a significant increase in educational effectiveness or efficiency. Ashby, Klees, Pachio and Wells (1980) found that with this type of use, the cost of television was prohibitive in relation to minimal increases in learning. In contrast, in Western countries where this pedagogical strategy was employed, research indicated a notable increase in learning.

Third World populations, including Caribbean populations, earn more equivalency degrees for primary, secondary and higher education than previously. Distance education provides adults and youths who cannot attend regular school classes an invaluable alternative to formal institutions. Distance education also provides instruction or specialized training for those individuals who require more knowledge than the formal system can furnish or disseminate. Although the British Open University is viewed as a model system, Bates (1980) found other countries should use different types of systems in order to tailor instruction. Distance education is successful when developing countries employ materials and a system of instruction which are responsive and relevant to local needs, culture and educational experiences. Therefore, British Open University materials and tutorial sessions were not unquestionably productive in Africa, Asia or Latin America.

Nonformal education is another crucial area of concern for developing countries. The development of public information programs in health and agriculture is mandatory. Communication must be timely and pertinent to the needs of a regional audience (AED, 1978).

The University of the West Indies Distance Teaching Experiment (UWIDITE) is a regional mass communications vehicle to share human resources and to alleviate problems of isolation. Problems of isolation occur through the brain drain from the smaller to the larger Caribbean countries, and from the rural to the urban setting within any one country (Stahmer and Lalor, 1987)

A part of a sociotechnical system of use approach to distance teaching appears through the special areas adapted to UWIDITE: teaching of the hearing impaired, teaching of reading; teaching of mathematics; and teaching of integrated science. There are academic, adult education and public information programs in order to introduce diverse individuals to the uses and potential of this type of educational technology. Unfortunately, the major flaws of this program are a result of a lack of technical and economic access to and control of media. These flaws reflect the importation of expensive, and sometimes inappropriate, equipment.

Limited Access and Escalating Costs: Variables Which Contribute to Foreign Control of Communications

Satellites can be utilized as a communication tool to extend radio and television signals to unserved, remote areas in order to provide public information programs in health, agriculture, etc. Caribbean countries tend to rent INTELSAT transponders to satisfy domestic communication needs which are related to formal as well as nonformal education (Ashby, Klees, Pachico and Wells, 1980). The lack of incentive to become involved in the domestic development of technology and programming revolves around the issues of control, access and cost.

Industrialized countries continue to exert their influence as the controllers, producers and distributors of communication equipment and programs. More developed countries benefit increasingly from innovations like teletext, etc. In the United States, the Federal Communications Commission has even allocated Ku-band frequencies for private use for independent business television networks within corporations. Ironically, the communication effects gap widens while Caribbean countries are constrained by the increasing costs of traditional broadcasting.

Although some technical equipment is cheaper, technological transformation is expensive. Third World countries, including Caribbean countries, do not manufacture communications equipment. Foreign exchange inequities exacerbate the problem. Caribbean countries cannot utilize outdated equipment when spare parts are unavailable. Places to train personnel on obsolete equipment are disappearing (Whitney, Wartella and Windahl, 1982).

Conclusion

In summary, the Caribbean countries exist geographically as islands, but they exist realistically as part of a global village. Long-range planning is an important tool to create a more equitable economic and educational exchange in the Caribbean. The long-range plan must encompass a sociotechnical system of manufacture as well as a sociotechnical system of use. Thus, a strategic segment of this plan is to use mass communications, specifically educational technology, to transform the Caribbean into a technologically literate region.

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Chairperson, Department of Communications

COMPUTER MUSIC AS A PATH TO QUANTITATIVE AND SCIENTIFIC LITERACY

The Fourth National Science, Technology, Society Conference

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Introduction

Scientists from the time of Pythagoras have been fascinated with and have studied the periodic relationships inherent in the musical scale. Research in the field of acoustics by scientists such as Kepler, Descartes, Galileo, Newton, Euler, Bernoulli and Helmholtz testify to this fact. Using the mathematical methods developed by Fourier, an understanding of how sounds are generated and differ from one another became possible. With such knowledge devices that synthesize and simulate sounds produced by musical instruments became a reality.

We propose teaching science and music to students in a way that parallels the philosophy and methods used in developing the Scientific and Technological Literacy (STL) program at Iona College. No music background is necessary. It involves the study of computer music as a path to quantitative, scientific, technological and musical literacy. Instead of just exposing the average student to music as in the traditional music appreciation course, we have developed a course that involves a "hands-on" approach for the average student to increase appreciation, knowledge, and skills in music and, at the same time, develop an understanding of science, technology and elementary quantitative methods that are intrinsic to computer music. The teaching is interdisciplinary involving a science faculty member and a fine arts faculty member in a team effort.

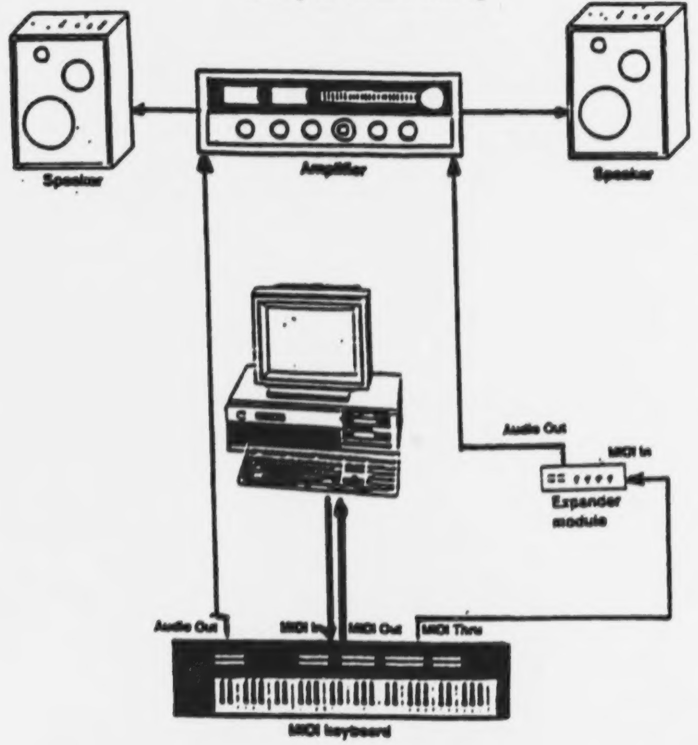
Using a computer with an internally or externally connected Musical Instrument Digital Interface (MIDI), the appropriate software and perhaps, a number of synthesizers equipped with MIDI interfaces, a variety of MIDI applications programs can be utilized. Music recording and performance software allows the recording of existing pieces, such as Bach, and the means for editing them. The computer can serve as a library to store sampled sounds which then may be studied in terms of an analysis of their complex waveforms, edited, and patched in where appropriate. Some software is also capable of printing the music as recorded by the computer, displaying it on the computer screen - staff, musical symbols, etc. Educational applications such as: tutorials on sight reading, musical notation and chord construction may also be developed. Interspersed with the applications of the MIDI software, fundamentals of science dealing with waves, sound, electricity, amplifiers, receivers, electromagnetism, speakers, recording media, computers, MIDI interface, synthesizers, coding and the associated quantitative methods are developed in an integrated fashion.

MIDI Interface

Central to the entire course is the exploitation of the MIDI interface. It provides both the novice and experienced player opportunities in expanding the sound capabilities of instruments and enhancing their own playing abilities.

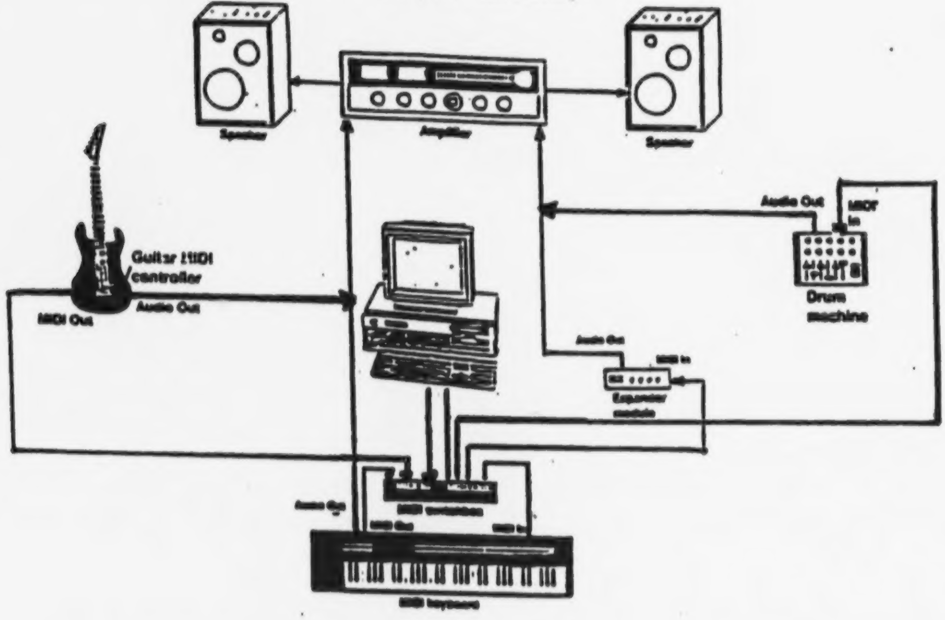
What is MIDI? MIDI is an acronym for Musical Instrument Digital Interface, a standard established by manufacturers of electronic musical instruments, that provides for compatibility among instruments of different manufacturers. It is characterized by a software and hardware set of specifications. In particular, the format of information transmitted through it is specified and also the type of physical connection, MIDI port, that is built into the instrument and the cable used to connect ports. It also specifies the voltage and transmission rate of the signals sent over the cables so compatibility will exist between instruments. Instruments that can receive and send MIDI codes are called MIDI devices. So any musical instrument can be a MIDI device provided it satisfies the MIDI specifications. However, the common characteristic of all MIDI devices is the presence of a microprocessor which is used to read, control, and send signals. Electronic instruments that do not have microprocessors, e.g. electric guitar, can be equipped with microprocessors so that MIDI messages can be processed. In addition, light displays synchronized to musical instruments and sound amplifiers can be equipped with MIDI interfaces and controlled. Computers are ideal MIDI devices provided they are equipped with the appropriate MIDI hardware and software.

Simple MIDI Setup



How is it used? The MIDI can transmit messages indicating when a key on a keyboard is first pressed, when it is released, and the nuances of the note played on the keyboard. Its messages can describe the pitch and loudness, of the note and whether any of the electronic controls on the electronic instrument are being used. Prerecorded scores or songs can be played together from several MIDI devices in synchronization. It allows the insertion of patches that have been previously stored to be used when desired. By connecting several MIDI musical instruments in series the quality or fullness of the sound may be enhanced. A computer equipped with a MIDI interface and appropriate software allows musical composition to be recorded in digital form, allowing for replay at a later time recreating the original. The computer also allows one to edit all the messages recorded so that notes played may be corrected and rhythms adjusted. In other words, you can record the piece by playing it very slowly and then use the computer for replay at normal speed, thus compensating for any playing deficiencies one may have. A complicated piece can be laid down on different tracks by the computer, i.e. bass, tenor, alto, etc., one at a time and then played back by the computer simultaneously. Once the piece has been edited it can be printed on paper in whole or in terms of individual parts. Sound samples can be recorded and edited and stored in the computer library and called upon when needed.

Complex MIDI Setup



In theory, an entire rock concert could be generated by one person with a computer and the appropriate MIDI hardware and software. Such a possibility is so seductive that students are motivated, receptive, and interested in understanding and mastering this new technology. There is immediate gratification and all sorts of opportunities for creativity and experimentation. This provides the "opening" to introduce the science of wave motion, its application to sound and complex waves. Microprocessors, computers, synthesizers and MIDI interfaces provide the motivation for studying topics in coding, electricity, receivers, amplifiers, electromagnetism, speakers and even the role of heat and optics in terms of different recording media.

The Course

The key to successfully developing scientific and technological literacy in this course is the integration of the science topics on a "need to know" basis within the course. The strategy we have developed involves developing first, a simple MIDI application with the associated skills followed by the development of the requisite scientific understanding and skills which allow for more complicated MIDI applications which, in turn, require more technological and scientific understanding. It is essentially an example of the spiral method for learning. The intrinsic interest that most students have in modern music provides the motivation.

Elementary quantitative methods including algebra, trigonometry, graphical analysis are treated as needed. Binary notation and coding are introduced when computer and MIDI messages are discussed. A two hour supervised laboratory session each week coupled with additional lab availability provide the "hands-on" experience for student fulfillment, development and mastery of skills, reinforcement of class lectures and fun.

The course may be given in a three or four credit format consisting of two or three hours of lecture per week and a formal two hour laboratory session. A typical model for the laboratory consists of ten laboratory workstations, consisting of IBM System 2- Model 25 computers equipped with the IBM Music Features card (a synthesizer on a card that includes its own smart MIDI interface, similar to the Yamaha FB-01) and two pairs of earphones serving twenty students, one pair to a computer, to attend each formal laboratory session. Several MIDI equipped instruments, such as a keyboard, should be available for input purposes. Considering its origins, the computer music course is unique in that it could be offered as a science or fine arts course depending on the emphasis.

Software presently in use include: tutorials from Electronic Courseware, **Sequencer Plus, Mark 3** (Voyetra Technologies) for recording purposes, **Personal Composer** (J. Miller) for composition, **Sample Design** (Turtle Beach Softworks) for sampling. Presently, no text is available and class notes, reprints, and outside readings are used. The authors are presently preparing a manuscript and laboratory manual based on the accompanying course outline.

COURSE OUTLINE

LECTURES

I. Computer Music and MIDI.
- A. What is MIDI ?
- B. What is a MIDI system?
  - i) Computers
  - ii) Synthesizers
  - iii) Drum machine
- C. What can it do?
  - i) Making music
  - ii) Recording
  - iii) Editing
  - iv) Creating
  - v) Printing music
  - vi) Patching
  - vii) Rock concert

II. What Is a Computer?
- A. Computer fundamentals
- B. Hardware
- C. Software
  - i) Computer coding
  - ii) Musical (MIDI) coding

III. Wave Motion and Sound.
- A. Generation
- B. Longitudinal and transverse
- C. Sound
  - i) pitch - frequency
  - ii) loudness, intensity, decibels
  - iii) reflection and refraction

IV. Music Fundamentals.
- A. Notes
- B. Half-steps
- C. Octaves
- D. Sharps and flats
- E. Keyboards
- F. Musical staff
- G. Rests, ties, and dots
- H. Dynamics
- I. Measures and time signatures

V. Interference and Diffraction.
- A. Superposition
- B. Constructive and destructive interference
- C. Traveling waves and standing waves
- D. Resonance
- E. Beats
- F. Musical Instruments

VI. Music.
- A. Notation and coding
- B. Sight reading
- C. Control words and symbols

VII. Synthesizers.
- A. Sound generators
- B. Microprocessors
- C. Keyboards
- D. Control Panel
- E. Controllers
- F. Memory
- G. FM synthesis

VIII. Electricity
- A. Atoms
- B. Charges
- C. Currents
- D. Ohm's Law
- E. Generators and alternating currents
- F. Electric power
- G Capacitance and inductance
- H. Amplifiers

IX. MIDI.
- A. Ports
- B. Cables
- C. Connectors
- D. Information transfer

X. Computer Applications Software.
- A. Recording and performance
- B. Notation and printing
- C. Editing and creating
- D. Tracking

XI. Amplifiers.
- A. Preamplifiers
- B. Controls
- C. Feedback

XII. MIDI Peripherals.
- A. Synthesizers
- B. Drum machines
- C. Instruments

XIII. Magnetism.
- A. Recording and playback media
- B. Tapes
- C. Records
- D. Compact disks
- E. Digital tapes

XIV. Speakers
- A. Cone speakers
- B. Enclosures
- C. Woofers, midrange, tweeters
- D. Baffling

XV. Examples of MIDI Systems.
- A. Consumer guidelines
- B. Review of current hardware
- C. Review of current software

LABORATORY SESSIONS

I. Anatomy of a MIDI System.
- A. Computer fundamentals
  - i) operations
  - ii) floppy disks
  - iii) loading and saving files
- B. Using software to edit music. A simple exercise.

II. Sound and Wave Motion Demonstration Lab.
- A. Longitudinal and transverse waves
- B. Sound and its properties

III. Music.
- A. Musical notation
- B. Reading music

IV. Synthesizers.
- A. MIDI operation
- B. Applications

V. Using the computer to record and edit.

VI. Using the Computer to createand edit tracks.

VII. Using the computer to create and orchestrate.

VIII. Electricity, Amplifiers, Receivers, and Speakers.

IX. MIDI peripherals.

X. Recording media.

XI. Project work.

XII. Project work.

The Role of Economics in Energy and Environmental Decision Making: An STS Perspective

Abstract

Contemporary energy and environmental problems continue to pose fundamental challenges to Western models of a successful pattern of life. From the perspective of an integrated study of science, technology, and society, energy and environmental problems can be seen more specifically to raise significant questions about economic decision rules as expressions of those models--i.e. as mechanisms for rationalizing traditional energy and environmental patterns of behavior.

After alluding to the range of historical, anthropological, and other questions an STS perspective raises regarding the role of economics in energy and environmental decision making, this paper briefly outlines a collection of flaws in the theoretical foundations for economic analysis as it is traditionally applied, concluding that its use in selecting among energy and environmental alternatives is a fundamentally circular rather than clearly deductive process. It is then suggested that our unwillingness to commit resources to experimentation with very different models of a successful pattern of life (specifically as related to energy and the environment) results more from a fear of abandoning a systematic and well established approach to decision making (i.e. economics) than from a sense that its guidance is necessarily optimal or reliable. Finally, it is suggested that an STS approach, by reinvigorating conversations among disciplines and between technical and non-technical people, could help to ease this fear and/or provide a partial substitute for existing frameworks in arriving at more sensible energy and environmental choices.

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The Role of Economics in Energy and Environmental Decision Making--An STS Perspective[*]

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Following a brief introduction, this paper will outline, from an STS perspective, a collection of fundamental flaws in the economic assumptions and analysis underlying energy and environmental decision making in the United States. A few observations will then be offered regarding our singular dependence on economic methods and our reluctance to step beyond their confines even in a spirit of experimentation. Finally, some preliminary suggestions will be made with regard to how the grip of economic perspectives on energy and environmental decision making might begin to be loosened.

Background and Introduction The environmental concerns of the 1980s have begun to carry us beyond aesthetic objections to dirty air and polluted water. Problems such as the depletion of ozone in the upper atmosphere, increasing CO_2 concentrations in the air, and acid deposition (including acid rain)--many of them strongly linked to the production and use of energy--now threaten global thresholds of stability [1] and portend more than inconvenience for future generations. Once in the realm of scientific speculation, these problems now also present us with actual forest death [2], startling holes in the ozone layer that protects the earth's surface from ultra violet radiation [3], and (arguably) the first stages of actual climatic change [4] that will (if it continues) soon take us beyond the range of conditions experienced in all of human history.

While the 1980s have also brought significant reductions in oil prices, we have yet to see any marked decrease in our dependence on oil as an energy source (oil accounted for 42.9%, 47.1%, and 46.1% of U.S. energy use in 1987, 1979, and 1973, respectively [5]), nor is there any indication that domestic oil production might again reach its historic peak of 1970. Instead, under increasingly precarious economic conditions accompanied by almost unprecedented federal deficit spending and a continuing balance of trade deficit, we face today a renewed growth in oil imports, now at around 41% "up from 31.5 percent just three years ago and near the peak of 48 percent reached in 1977 [6]." Conservation efforts and the higher prices of the 70s and 80s put such a damper on energy use in this country that total consumption in 1986 was roughly equivalent to consumption in 1973 [7] but this "success," in turn, seems to have contributed to more recent price drops, returning us to growth in energy consumption and further paving the way to another round of crises.

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These and other energy and environmental problems are severe, pervasive, and apparently stubborn enough to raise questions about the forms of economic analysis that underly or are used to justify most public and private decision making. The analytical adjustments implicit in the increasingly stringent environmental legislation of the 70s and 80s and in technology assessment and other efforts to broaden the calculus of social decision making have so far proven inadequate and our questions about economic methods must be carried to a more fundamental level.

Indeed, energy and environmental problems can be thought of as products of a complex but unified cultural fabric of science, technology, and society. From this perspective, the economic methods developed as a part of that fabric need as much to be examined as a potential part of the problem, as they are employed in the selection of solutions. Adopting an STS perspective on economics as it is applied in energy and environmental decision making in fact raises a number of important questions. One may ask, for example, how present economic paradigms came to be accepted historically and how they came to occupy the dominant position [8] they now hold in decision making contexts. How, that is, did 19th century efforts to apply scientific methods to the improvement of society result in the academic discipline and professionalization of economics as we see it today [9]? How is it, one may also ask, that we do not subscribe to the economics of "specific, limited objectives," characteristic of various "primitive" cultures and characterized (according to Marshall Sahlins classic study, "The Original Affluent Society" [10]) by a surprising abundance of leisure time? How is it that we think in terms of efficiency and return on investment while the Romans frequently failed to consider interest on loans and regarded the specialization of labor as a means to superior craftsmanship rather than a way to increase labor productivity [11]?

Another way to bring an STS perspective to bear on the role of economic analysis in energy and environmental decision making is through a direct examination of the theoretical foundations of the analysis itself. Does the analysis rest on foundations beyond the bounds of the cultural patterns that have led to energy and environmental problems, or is the analysis itself ultimately caught up in those patterns? The next section of this paper presents in a very abbreviated from, an attempt to answer this question [12].

Flaws in the Economic Perspective A major component of the theoretical core of economic perspectives on energy and the environment is found in what economists refer to as "optimal depletion" theory (in spite of the apparent contradiction in terms). A brief review of problems with this theoretical foundation provides an indication of a collection of problems that do appear to plague economic perspectives as they are applied to energy and environmental issues.

Through fairly sophisticated mathematical manipulations, optimal depletion theory attempts to derive conditions for maximizing the social benefit derived from a depletable resource, where this benefit is defined as the difference between what people are willing to pay for the resource and what it costs to make it available for use. One of the central conclusions of the theory is the idea that properly functioning markets will lead to resource prices that will result in an optimal allocation (depletion) of the resource over time.

To the non-economist, many of the assumptions incorporated in optimal depletion theory may be surprising. It is generally assumed, for example, that a "backstop" fuel or energy technology exists and will become available at a socially affordable cost as conventional or non-renewable energy sources are depleted [13]. Without this assumption and, in addition, assumed future price levels for the backstop fuel, the theory would have no claim to say whether or not current prices ensure an optimal depletion path. The possibility that backstop fuel prices may be a strong function of conventional energy prices is, moreover, not generally recognized by the theory. (Such a functional relationship is strongly suggested by the work of Costanza [14], Cleveland et al. [15], and others, and arguably by time series comparisons of "conventional" and "alternative" energy prices.)

Beginning with the earliest formulations of optimal depletion theory in 1931 [16], it has also been assumed that the willingness to pay for energy will never be infinite. This assumption, without which the mathematics of the theory break down, is roughly equivalent to assuming not only the existence of an affordable and socially acceptable backstop fuel but to the further assumption that a transition to that backstop can be managed without the severe social or economic dislocations that might lead to third world food shortages or other threats to life contemplated in less optimistic future energy scenarios.

At a more formal level, economists [17] generally assume in the development of optimal depletion theory that there are no serious externalities, environmental or otherwise, associated with the production and use of energy. In some cases [18], externality considerations are later introduced through "adjustments" in the basic conclusions of the theory. As the respected economist William J. Baumol [19] has noted, however, this approach is not valid mathematically. Conditions for optimal depletion derived on the basis of an assumption of no externalities may be entirely invalid in the presence of externalities.

Also troubling is the failure of accepted theoretical formulations to differentiate in the definition of "social benefits" between "willingness to pay" for particular resources and "ability to pay" [20], and between the allocation of non-renewable resources at a given time and the distribution of the benefits and costs of resource use among people at different times [21]. The interests of third world peoples and of future generations may be seriously underrepresented as a result of this confusion.

One more assumption, employed not only in optimal depletion theory but throughout economic analysis, deserves special emphasis--i.e. the assumption that future costs and benefits must be "discounted" in comparing them with present costs and benefits. In extreme cases the number of lives lost in the future in conjunction with nuclear power production has been "discounted" and taken to be equivalent to a much smaller number of lives lost in the present [22]. In optimal depletion theory, a more generalized discounting of future social benefits derived from energy production and use is assumed. In both cases, the adoption of discounting occurs without apparent theoretical justification [23]. By way of explanation, economists sometimes point to the empirical fact that most people one might stop in the street would be willing to trade a dollar in income now for something more than a dollar in guaranteed income in the future. (The future income is effectively discounted to get its present value.) Discounting may also be a logical procedure under an assumption of continuing growth in per capita income--i.e. under an assumption of continuing improvement in economic conditions. One need not look far, however, for examples of situations in which the practice of discounting would seem entirely inappropriate. Anyone anticipating an economic crash analogous to the one in 1929 would surely prefer future benefits (benefits to be received in times of scarcity) over present benefits of the same scale (in times of relative plenty).

Many of the difficulties just outlined make optimal depletion theory and the classical economic approach to energy and environmental decision making a fundamentally circular form of reasoning at least with respect to long range decisions. If we assume at the outset that an affordable backstop fuel exists and that a smooth transition to that fuel can be made, the conclusion that the optimal path lies in a reliance on market pricing mechanisms may be relatively unremarkable--and such a conclusion certainly does not support expectations for the smooth transition initially assumed. If we further assume that severe shortages will never occur (i.e. that "willingness to pay" will never be effectively infinite) concerns about such shortages cannot be a basis for questioning market allocation of non-renewable resources and it is inappropriate to conclude that market allocation will avoid severe shortages. Finally, if we assume continuing strong economic growth (the most logical rationale for discounting the future) it should come as no great surprise that analysis dependent on our assumptions forces no significant revisions in present patterns of behavior relative to energy and the environment even in the face of physical signs of resource depletion and extensive environmental damage.

Economists often respond to this kind of criticism by noting that it is old news--i.e. that economists are generally aware of these problems with their analysis. Much to their credit, individual economists have, in fact, advanced essentially all of these criticisms at least singly; a few [24] have even raised the kinds of questions presented here about the overall usefulness of the traditional analysis given the cumulative impact of all of these criticisms taken together. Economists will generally admit and even insistently warn policy makers, as well, that their analysis best applies to decision making at the margin and is not well suited to answering long range questions that could involve significant departures from the data available under current market conditions. Unfortunately, long range decisions often get made in this country by default--i.e. as a simple accumulation of decisions at the margin. This effect surely is evident in the history of energy and environmental decision making over the past 15 or 20 years since the OPEC embargo and the early days of the environmental movement. Under these circumstances, economists and other analysts have a responsibility to make the limitations inherent in the circular nature of economic reasoning as it is (de facto) misapplied to long range energy and environmental questions much more clear to both policy makers and the public.

To summarize the problem along lines suggested by economist Herman Daly [25], energy and environmental decisions are price determining and for this reason prices form an uncertain if not highly imperfect basis for energy and environmental decision making. Energy prices, in particular, are heavily influenced by our collective beliefs and assumptions regarding such things as future economic growth and the feasibility of, and ease of transition to, "backstop" energy alternatives. Long range energy and environmental decisions based on prices strongly echo these beliefs and assumptions without directly examining them in the light either of current problems or of recent experience. The analysis itself, in answer to our initial question, is caught up in the cultural patterns from which it has arisen; as such it cannot be expected to provide a sound standard by which to judge the adequacy or wisdom of those same patterns.

Reliance on Economic Perspectives Our reliance on market prices and economic analysis as a basis for energy and environmental decision making is so entrenched that it is even allowed to restrict the range of research in the social sciences. In their charge to the National Research Council study, Energy Use: The Human Dimension [26], for example, the Department of Energy stated flatly that, "Economic paradigms, together with assessments of the potential contributions of new and existing technologies, will continue to provide the basis for the analysis of alternative public policies relating both to energy production and consumption;" researchers were encouraged to pursue noneconomic behavioral and social science perspectives only insofar as they might "contribute" to "such analyses" [27].

Given the fundamental weaknesses in economic perspectives, including those outlined above [28], how is it that we continue to rely on economic analysis so heavily? Two possible (partial) explanations will be suggested here.

First, an economic approach is traditional in our society. As such, it tends to be accepted, without much examination on the part of the public at large, as a virtual embodiment of "rationality." While there are plenty of examples of societies in which modern economic concepts and desiderata would be incomprehensible [29], such examples tend to be popularly dismissed as historically backward or "underdeveloped." As individuals, we tend to treat market prices as natural phenomena comparable to the strength or hardness of a metal alloy, and fail to recognize the degree to which they are a function of social conventions and collective beliefs. Our reliance on an economic approach is also expressive of traditional power relationships in our society. The population at large is understandably not anxious to participate in a close analysis of social options if that analysis might lead to a convincing case for accepting immediate sacrifices in the interest of long term energy and environmental benefits. Similarly, expert decision makers, essentially satisfied with their social and material situation, are understandably not anxious to stir public participation--nor are they unduly burdened by a sense of moral responsibility for undesirable outcomes, thanks to disciplinary blinders and the dissolution of accountability associated with specialization, "committee" decision making, and other aspects of the decision making process [30,31].

A second explanation for our continued reliance on a fundamentally flawed approach to energy and environmental decision making is an understandable reluctance, especially in times of stress and uncertainty, to abandon what once appeared to be a tried and true "method." It is difficult, at best, to put aside methods that have brought us unparalleled prosperity, in favor of relatively *a*methodical and hence (by conventional standards) inefficient--even experimental--attempts to develop new patterns of behavior with respect to energy and the environment. Such a prospect may be very threatening both to traditional decision makers, whose legitimacy depends on acceptance of the methods they apply, and to ordinary citizens accustomed to a well ordered existence and the image of a comparatively secure future.

Efforts to avoid the relative chaos of competing claims in an energy or environmental decision making context not tightly adjudicated within a framework of economic analysis, however, do *not* avoid the fundamental flaws in such a framework. Neither are such efforts likely to prevent the energy and environmental consequences--present or future--of a continued reliance on economic perspectives.

Suggestions for the Future Examination of the theoretical underpinnings of economic analysis as a framework for long range energy and environmental decision making suggests that there is no reason for timidity in proposing actions inconsistent with such a framework. In fact, a much more assertive presentation of alternative perspectives appears justified both theoretically and by what appears to be the continuing practical failure of the traditional framework to grapple with energy and environmental problems (a failure sketched only briefly in the first paragraphs of this paper). In pressing for recognition of competing claims it should be somewhat reassuring to recall that democratic "methods" for choosing a course of action in this country predate and take legal precedence over methods based on a comparison of benefit/cost ratios or other economic measures.

A relatively modest loosening of normal cost effectiveness criteria in choosing energy systems and making choices affecting environmental quality opens a surprising range of possibilities in, for example, the area of systems combining vigorous energy conservation with renewable energy supplies. In cases such as this, as we move away from strict comparisons of costs per kilowatt hour for, say, photovoltaics as compared with coal-fired electric generation, it may be useful to think in terms of the alternative criteria of "affordability" and "attractiveness" [32]. Comparisons could be drawn, for example, between the cost of a residential photovoltaic system, including appliances optimized for an expensive electricity source, and the cost of conventional power in an ordinary context of inefficient electricity use. A kind of breakeven cost analysis would then be possible, asking whether or not the absolute cost penalty for the conservation/renewable energy combination is worth the energy and environmental (e.g. reduced CO_2 emissions) benefits such alternatives would bring.

The recent expiration of conservation and renewable energy tax credits suggests that, from a federal perspective at least, the period for experimentation with energy systems that cannot immediately compete in the marketplace is over. The Reagan environmental era, with its emphasis on deregulation and (some would say suspiciously selective) budget reductions [33], has at least temporarily limited conventional environmental protection efforts to a very narrow economic standard, as well. There are continuing signs, however, that a market approach will not generate solutions to increasingly pressing energy and environmental problems. While costs cannot be ignored, restricting analysis to alternatives for the future that are viable in a conventional market sense is both practically and theoretically unjustified.

More importantly, perhaps, such restricted analysis improperly limits the kind of participatory experimentation, mixing people and technologies, that might greatly enhance more methodical "laboratory" approaches to the development of new and more sustainable patterns of life.

By expanding the domain of analysis, STS perspectives on energy and environmental problems (and on the role of economics in addressing them) can be an important element both in refining our understanding of the problems we face and in suggesting alternative scientific, technical, and social avenues to be explored. In stepping across and beyond conventional disciplinary boundaries, STS perspectives offer opportunities for more realistic and productive assessments of Western models of a successful pattern of life. By reinvigorating conversations among disciplines and by opening the discussion to historical and other alternative models, STS perspectives also greatly enrich the experiential base from which innovation and experimentation might be drawn. In both respects, STS perspectives can help to bring some coherence to the inevitably messy and unsettling process of forging both more immediately effective cultural responses to energy and environmental problems, and more generally sustainable patterns of life in the West and elsewhere in the world.

NOTES

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4. Wilford, John Noble, "His Bold Statement Transforms the Debate on Greenhouse Effect," New York Times, August 23, 1988, p.C4.

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8. The "dominance" of economic perspectives in energy decision making has been described as follows: "...In most aspects of the national policy process, the commodity view [or economic view of energy] is dominant. Dominance of a particular view of energy does not mean that it is the only view given consideration, but that other views must make special claims before being taken seriously. And in most U.S. energy policy debates, the burden of proof still remains on those who assert that energy should be treated as something other than an ordinary commodity. When these advocates succeed, they do so by winning exceptional treatment for particular situations rather than by changing the dominant perspective." Taken from page 23 of Stern, Paul C., and Elliot Aronson, editors, Energy Use: The Human Dimension, Committee on Behavioral and Social Aspects of Energy Consumption and Production, National Research Council, W.H. Freeman and Company, New York, 1984.

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12. For a more complete treatment, see Tatum, J.S., "Energy, Economics, and the Environment Revisited," Draft Research Report, Energy and Resources Group, University of California, Berkeley, September 1986.

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23. The "argument" provided by Krutilla and Fisher [Krutilla, John V., and Anthony C. Fisher, *The Economics of Natural Environments: Studies in the Valuation of Commodity and Amenity Resources*, Resources for the Future, Washington, D.C., 1985, p.60.] is typical: "In its simplest expression, a dollar currently in hand has a higher present worth than one promised to be available only after a time lapse. Similarly, the present

value of benefits today is greater than equivalent benefits, reckoned in constant dollars, expected to be received in the future."

24. Notably Herman Daly (see specific references above and below).

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26. Stern, Paul C., and Elliot Aronson, editors, Energy Use: The Human Dimension, Committee on Behavioral and Social Aspects of Energy Consumption and Production, National Research Council, W.H. Freeman and Company, New York, 1984.

27. Ibid, p.vii. Chapter 2 of Stern and Aronson provides a more detailed outline of the dominance of economic perspectives in energy decision making.

28. An excellent and more general critique of economic perspectives has recently been provided by McCloskey, Donald N., "The Rhetoric of Economics," Journal of Economic Literature, Vol.21, June 1983, p.481-517.

29. See, for example: Finley, M.I., op cit; Sahlins, Marshall, op cit; or, for a description of the transition from one set of governing concepts to another, Polanyi, Karl, The Great Transformation, Beacon Press, Boston, 1944.

30. In an analysis of traditional decision making among the Gwembe Tonga, anthropologist Elizabeth Colson has argued cogently that a traditional reliance on diviners and ancestral shades serves the important function of ensuring tranquility for the decision maker who has--independent of outcomes--at least made every effort to follow the "correct" procedure. She also suggests that a reliance on statistics and analytical methods (economics?) may serve similar ends in Western societies without, in many cases, any claim to reliability superior to that of a diviner's consultation with ancestral shades. [Colson, Elizabeth, "Tranquility for the Decision Maker," Cultural Illness and Health, Laura Nader and T. Maretzki, editors, 1971.]

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The STS VIRUS: it needs to infect the structure of education.

by Terry Born and Paul Jablon

In today's society education is a mass of contradictions. As the world seems to grow smaller through advances in transportation and communications technology, our young people are growing further apart from one another and more and more alienated from their environment. As our capabilities for control over data expands, the numbers of people with access to that control is decreasing. We find ourselves no longer active seekers of new ideas but rather the passive recipients of predigested information. The challenge for educators who understand the importance of Science, Technology and Society to the future of education is to tap into the problems and possibilities of tomorrow's world and harness our knowledge into an active, participitory experience which empowers students to make the best possible decisions and changes for the future.

This seems to be an obvious statement. Naturally, we feel that we are doing this by introducing the latest computer systems and satellite technology to our students. We feel that by infusing curriculum with ideas about the appropriate and inappropriate uses of nuclear energy, robotics, and socialism, we are educating our students to utilize these tools to create social change. In fact, the very nature of these devices and ideas serves to detach the user from that special *personalization* so vital to exciting the minds of real learners. If one thinks back to the Renaissance or the Age of Enlightenment, one is moved by the emotional connotations associated with those time periods. That emotion came, in good part, from the real power that rediscovery, and rational thought endowed upon it's users. Today, technology gives us more power than had ever been conceived, yet the overwhelming sense in so many of our schools, as exhibited by societal symptoms of dropout rates, drug use, crime, suicide and illiteracy is that the majority of the students find, or choose to find, New Age Learning inaccessible and are powerless or care-less in confronting its possibilities.

If we are to teach Science, Technology and Society we must examine our methods of teaching. The nature of the content demands a new style that stimulates emotional, personal participation and allows learners to incorporate knowledge into their lives by making it an effective tool for change. In order to do this successfully we must make the personal connections between technology and social action and students' lives crystal clear. We must make active use of technological and social tools for social and environmental impact a part of our daily curriculum. And in order to make these changes possible, we must look at the way our schools are structured and break away from traditions that no longer serve to make learning creativity and reform dynamic forces in our every day lives.

Students come to school with their lives on their backs. Unlike the clear slate you write upon as a teacher, the recipient of your knowledge is a jagged, globular conglomeration of intellectual and emotional needs and desires. From time immemorial the teacher has approached the students as being as blank as the slate beneath her chalk. We assume that they will simply absorb the words and equations we write on it or speak at it and then they will "know" the magic formulae. In reality we find that the blank slate has a hundred different and varied needs, very few of them being the acquisition of the "magic formula" we are about to feed it. We teach under the assumption that all of our students are in need of self-actualization and that our knowledge will permit them to become so. Yet anyone who is even romotely familiar with Maslow's Needs Theory understands that unless you cater to the lower hierarchy of unmet needs , a person cannot and will not respond at a higher level. Our students are operating at a level of fulfilling the emotional needs of esteem and love, and yet schools continue to operate in environments that refuse to respond to the need to couch the self-actualized ideas in this milieu. Single parent families and the ever increasing power of negative peer group pressure mandates that we include ways that students will fulfill some of these needs in accessing the STS skills and knowledge we are presenting. Our students need love, esteem, and new languages for communication. Ironically, it doesn't mean we teach a different set of knowledge, what it means is that we go about it so that the knowledge is transferred in a different **style.**

A key strategy is to create an "interactive" backbone for the classroom. By involving students from day one in a personal participatory activity that is linked to the academic, social, or technological information to be learned you answer the emotional needs of the learners while showing them a way in which to utilize their classwork in achieving a goal. The society of the classroom is a real social order in their lives, yet it is rarely viewed as such. In this day and age, where the individual is tuned into the solo experiences of walkman, watchman, computer screen, and VCR, it is essential to open students up to the potential of the group.

Groups are vehicles for action, they are vehicles for creativity and they are vehicles for emotional support. Studies by experts in collaborative learning, such as those by Alfie Kohn in *No Contest. The Case Against Competition,* indicate that competition is not always the best motivational strategy. Cooperation has been shown to be equal, if not more effective as a tool to help students over the rough spots. By creating an atmosphere of shared responsibility you insure the group's growth as a whole. Acquisition of skills and information becomes a shared experience. Incidentally, you are also teaching the kind of social responsibility and social consciousness which is the backbone of STS philosophy.

One of the easiest ways to involve a group in the learning process and engage them in each other's acquisition of knowledge is to create a need to work together. The obvious answer is a class that centers around a group project. A publicly presented project enables the group to make immediate, relevent use of the information learned. It can provide the common goal that unites the varied skills, interests and personalities of the class and highlights the differences making individuals complementary as opposed to competitive. It instills the concept of commitment on both a social and a task completion level.

Projects should be do-able and should make an impact and provide a platform where students express their hypotheses, as well as informed political, social and scientific beliefs. A class in ecology which is centered around the investigation of local marine life can become involved with the politics of the community. A social studies class which examines the impact of welfare laws upon urban society must become involved in meeting the needs of the homeless or the efficacy of our social systems. The key point here in the "new-style" approach is that examination and study, surveys and reports are not enough. Information is no longer valuable or exciting in and of itself. It must be able to be communicated. It must go out to the community. Students must be empowered with an active voice.

This brings us to the second necessary change in teaching style. School has traditionally been seen as an isolated, detached incubator where children and young adults are kept segregated from the real activities of life. In recent years, with the proliferation of community based internship programs we are seeing a small change in at least the career preparation area of education. The success of these career programs in giving young adults tangible options for the future and in counteracting the perennial problem of how does one get a job, has caused some educators to look at other areas where **doing** is as important to learning as the actual information that one acquires. In operational internship programs throughout the country, students learn about the job by being on it. Training is not only learning from a text or teacher, it is the actual experience of performance. This concept is readily applicable and necessary to the teaching of STS.

We complain that young people are apathetic in the face of government, do not avail themselves of the basic rights afforded them in the Constitution, do not investigate or have opinions or take action for or against technological or environmental issues which impact directly upon their lives. Yet in educating them with facts, we do not in any way take them through the processes which give them the voice and the strength to take a stand, begin a change or move a cause. Can you imagine a class in bicycle riding where no one ever got on a bicycle or a class in conversational Spanish where no one was allowed to speak to one another in Spanish. Yet both these activities are filled with fewer complexities and social and psychological baggage than the interactions involved in operationalizing the STS model into a life situation. Time and time again, we have sat in classes where nuclear energy or nuclear disarmament are being discussed and where classes dutifully take down the numbers of missiles stockpiled; the numbers necessary to kill the population of New York State, Canada, the world, the length of a nuclear winter, the half life of plutonium. When asked to describe how that makes them feel, what we should do with these bombs, or how many we should continue to build, the powerlessness in the face of the numbers, governmental control and the power of fear is seemingly insurmountable. The discussion is seemingly futile. "We have no control." "We have no voice." is the cry that we hear in their silence. It is, in fact, irresponsible to teach facts like these without teaching empowerment. Without that skill, the lesson becomes pages five through ten of their class notes, to be kept till next month when we begin to study acid rain.

What if classes were designed where STS issues were not only learned, but were acted upon. The vitality of STS comes from its controversial and personally impactive nature. Studies of erosion, pollution, appropriate use of and misuse of energy sources or genetic manipulation must be taught hand in hand with the processes of political action. If we are to present controversial issues in the classroom, we are obligated to teach ways in which to voice our concern, communicate our support and effect social change. It is not enough to teach that things change; we must educate the students into becoming the instruments of change. We must allow them to start participating while they are in school.

This can be accomplished through the projects. If classes or schools had ongoing high-quality newspapers, magazines, and theater groups which incorporated community in their activities we would be giving students a forum where they could be heard. The activities need to be part of the required curriculum, so that students understand that the process of using their knowledge to inform and entertain are real ways to make a social impact. They must be educated in the art of translating; to see that sometimes dry information can gain new personal content when place into a more artistic context(poetry, drama, art, photography). In other words, first role play a community board meeting in the classroom. This week long simulation is followed by students regularly attending and testifying at real board meetings. Meanwhile, another set of classes are publishing a 24 page community newspaper or tv program where issues that they have done investigative reporting about are aired. Before, during and after these activities the "concepts" and "information" is learned

The other need is to fully utilize the available technology. Just as we deny students a voice in the community we curtail their use of technological equipment to its fullest potential. Computers at many schools are used for word processing. This is a wonderful tool, which raises self concept, improves writing skills and motivates many non-writers to be able to express themselves in a clear, concise form. But the computer has more potential than it's use as a writing implement and certainly more than it's common use as a practice tool for memorizing factual information. Simulations that allow students to experience the multiple repercussions of a decision made in the legislative sector or earth resources are incredibly powerful tools in comprehending the matrix of interactions. Some computer programs exist that allow students to do this with such issues as water resource management or deforestation, but they are the exception rather than the rule. Schools with satellite disks need to use them to send telecommunications as well as passively receive programming. Video equipment which **transforms** the classroom into a monitor for a universe of films, documentaries, special features, etc, also needs to be a **transmitter.** It is important that students become aware of and skilled to make films, documentaries, record special sessions and create simulations of their own based on STS issues. As the world gets smaller the fax machine, satellite disk and modem can interconnect schools and special programs so that networks of students across the country and around the globe can be involved in a dynamic learning system. This is not the future. There are now high schools in a worldwide network, but they can be counted on one hand. Technology must not be confined to its minimum passive use, it must be expanded to its maximum potential. As we deny students a voice in affecting their communities, we likewise restrain their experience with technology and restrict their global potentials.

In order to make these **new styles** an integral part of school curriculum it is necessary to rethink some of the basic traditions we have adhered to. The system as it is defined by most schools today is a throwback to a time when competition and passive learning were prized as high quality education. It is all too clear that these values are not enough to bring the disenfranchised, neglected, bored and socially unproductive youngster back into the fold. As the world is changed from moment to moment by technological advancement, social unrest and natural upheaval, it is time to evolve the structures of school into a system which accommodates these changes. We must stop addressing symptoms such as drug addiction, truancy, and inappropriate behavior, and begin to make the source a more flexible holistic activity center. Administrators and teachers ,in a collaborative,must begin to question elements of the structure in order to reassess what is best for today's youth. Is the 40 minute time period for the class always best? Or does a

70 minute period allow for real ACTIVE involvement? And how about space? Is the traditional classroom with desks in rows always best? Should classes always be taught as one distinct unconnected discipline such as mathematics or American History?

Administrators must also begin to look towards the business community for guidelines in adapting new styles to an old system. A business will try out a new system if they know that it will result in an increased profit. A profit for the school system is an increase of motivated, well-informed, skilled graduates. It is time for educators to take the same risk. We need to spend time and money for research and development of new programs that will ultimately profit individual students as well as the society at large.

The experience that we have had has taught us that the key to education in today's society is flexibility. You must listen to your customers, the students, and respond in a way that makes sense to them. What their disenfranchisement has said to us is that we are not sending them out into the world with the skills and the voice that they need to cope with it.

If you are interested in joining a coalition of schools creating programs that fit and modify a new **flexible paradigm** that accommodates much of this discussion, please contact the authors about the **2000 AND ONE** Project c/o The BONGO Program, Middle College High School, 31-10 Thomson Avenue, Long Island City, New York 11101.

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MULTI-MODAL LEARNING: A LEARNING ENVIRONMENT FOR THE 21ST CENTURY

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A paper presented at the 4th Annual Technological Literacy Conference for the National Association for Science, Technology & Society, February 3-5, 1989, Washington, D.C.

"The Science Report Card," a federally funded project conducted by Educational Testing Service of Princeton, N.J., reported to the federal government in September, 1988 that only seven percent of American 17-year-olds have sufficient skills to do well in college-level science courses. Other age levels and populations were studied in this project, and, as each of the data sets were analyzed, the results painted a rather bleak picture of the science education programs in our nation's schools.

Another report issued by the National Research Council, the research arm of the National Academy of Sciences and Engineering, stated that from the eighth grade on, the percentage of students taking mathematics and science decreased by half for each year of schooling. This decline means that each year fewer and fewer students are taking courses that are necessary for careers associated with technology. We are at risk of becoming a nation whose education system does not support a productive, technologically powerful work force.

Report after report calls for change, and changes have been instituted. It is, however, not sufficient to simply improve traditional programs, but to, also, make changes in our two hundred year old set of classroom rituals. For example, the most prevalent form of teaching, lecturing by a teacher, is the least effective way for the student to learn science or mathematics. This method should be replaced with systems in which the teacher is a facilitator who gets students motivated to learn.

As a science educator in our public schools for over twenty years, I'm not surprised with the results of the studies. A time traveler from the eighteenth century would feel very comfortable sitting in any of our nation's classrooms. In other words, our educational delivery system has not changed significantly in nearly two hundred years. Students still sit, listen and copy notes basically the same way our parents' grandparents did two centuries ago because methodologies and teacher expectations have remained basically the same.

We have added some technology to our classrooms: video tape recorders, microcomputers and even laser disc players. But have our teachers changed their instructional style to effectively utilize these marvels of the information age? Better yet, have our teachers redesigned classroom environments to match the new learning styles of a nation's students who can not imagine a world without television, video games or microcomputers?

If you read the studies conducted by Douglas Ellison and John Goodlad's book, A Place Called School, you will find these researchers calling for a nation of educators who are willing to be the "risktakers." What is needed are changemakers who will activate the vision of an educational system geared to develop informed citizens in a 21st century scientific society.

The hunger of educators for stability is entirely natural. Change is scary; uncharted change is even more demoralizing. Our system of education has always championed itself for its lifelines to the past. Even in a world of technological advances, educators instinctively defend themselves against disruption. When research finally drives out old opinions and legends, teachers still take care to graft the new perceptions to ancient ideals in order to minimize the shock to our system and to preserve continuity.

How can we stand still in education when the whole world around us is changing? Many of our teachers remember the first transcontinental airplane flights and saw on television the first men to land on the moon and roam the frontiers of space; some can remember the first mechanical computer and today carry their own microcomputers to school in their briefcases. Most will remember the first atomic bomb and today light and heat their homes with this same form of energy. Why, then, are these same educators not willing to cast aside the traditional classroom format and become educational pioneers? Most have not chosen to be "risktakers," however, once in a great while, someone is willing to take a chance on changing the future. The study I am about to describe concerns one of those pioneers.

About four years ago, I had the good fortune to see an overview of a unique program about whales that changed my thinking about how children should learn science, or for that matter, any subject area. That program, "The Voyage of the Mimi," sparked my imagination and I was hooked on the style, substance, and scope of this program that had the potential to turn kids on to the learning processes. Sam Gibbon and his staff at the Bank Street College of Education had developed what I now call "the multi-modal model" of learning. From this first exposure to the "Mimi", it was obvious that the people at Bank Street had created the necessary components to develop a new model for classroom learning.

Within a few weeks, I had EESA federal grant money and had convinced a regional consortium of school districts to order enough copies of the videos, computer software and books to start this program in over a dozen schools in the north central region of Pennsylvania. As teachers started to use the "Mimi" materials in their science curricula, meetings were held at the local Regional Computer Resource Center to share their classroom experiences. After attending a few of these sessions, however, I felt that the

"Mimi" project was being used to supplement the standard format of the traditional classroom environment using the lecture, demonstration and controlled laboratory experimentation methodologies. The folks at Bank Street had more in mind for this project than a simple extension of traditional instructional methodologies.

With the promise of additional technology in the form of microcomputers, modems, microcomputer-based laboratory equipment, laser discs and players, LCD overhead projection panels and my support, I convinced one of our local seventh grade science teachers to challenge the potential of the "Mimi" project and seek out new ways to involve his students in learning science.

Four classes, totalling 101 seventh graders, were involved in the pilot study. The classes were grouped heterogeneously with a nearly equal number of males and females. The teacher/experimenter started the academic year by having his students investigate the various sources for obtaining information about science. From textbooks to on-line computer searches, students were given opportunities to do research. The use of technology in the pilot study generated a tremendous amount of excitement with the students.

The on-line data searches were shared with the entire class via the overhead computer projection panel. Students were involved in every aspect of the searches from the logging on procedure to the printing out of the data. During this initialization process, students were actively engaged in learning to use a variety of resources that scientists need in "doing science." The use of printed materials to build their vocabularies and scientific backgrounds, diagrams and graphs to explain complex processes and technology-generated media to help develop their formal thinking skills were important increments in creating a broad-based foundation for the multi-modal learning environment. As an observer, this was also a time when the teacher/experimenter was developing the various roles with his students as a senior researcher, classroom activator, facilitator of laboratory activities, and, most importantly, as a learning mentor. Enthusiasm can be contagious.

After this two week period of developing research skills, the "Voyage of the Mimi" was introduced in full living color. As luck would have it, the local PBS television station was also broadcasting the series. Students easily identified with the cast of characters and it wasn't long before the crew of the Mimi became part of the class. Students referred to the crew members in their classroom discussions and often related the crew's experiences to their laboratory activities. The "Mimi's" characters were so close to reality that most students found them to be very relatable in the video component of the project.

At this point in the pilot study, the multi-modal model of learning evolved as a unique style of classroom learning. In retrospect, the multi-modal approach developed around optimal student attention time - that period of time when students are cognitively engaged in a meaningful learning activity. Research has indicated that most students have an effective attention span of about 10-12 minutes on any cognitive task.

This concept, then, became the key factor in creating the classroom sessions. The teacher/experimenter divided each 42-45 minute classroom period into three distinct learning sessions using the following instructional modalities: presentation, activities and class discussions. Each modality stressed the use of technology as a tool for learning and required a high degree of student interaction. In each of the classes, the modalities were linked together with a central theme to ensure concept development and the associated science process skills. The teacher/experimenter had to carefully plan the type of presentation to be used, the manipulatives activities supporting the concept development and the kind of questions used to initiate the discussion period.

Throughout the next twelve weeks, the "Mimi's" learning modules were correlated with the existing science curriculum. Students were "doing science." They were doing the research, collecting the data, analyzing it and drawing their own conclusions. The teacher/experimenter enhanced the pilot project using additional microcomputer-based laboratory activities, the National Geographic laser disc entitled, The Whales and other hypermedia programs developed by the students.

As the teacher/experimenter completed the final module of the "Mimi", he continued to use the same classroom approach for the remainder of the academic year to complete the units in his science curriculum.

With the end of the school year, the science teacher and the project director felt that the pilot study was so effective because of the student enthusiasm, parent involvement and staff excitement that it was decided to quickly seek a measure of student achievement. Since the Iowa Test of Basic Skills was to be administered at the end of the year to all seventh grade students, the science component was also included. It was decided that if the pilot study had any effect on student science learning, the test would indicate a higher achievement in science when compared to other academic areas. When the science test scores were analyzed and compared to the students' scores in the areas of mathematics, social science, reading and work study skills, there was a distinct positive clustering of the science test scores

INSERT TABLES HERE

An examination of the science test results showed that most were grouped toward the high end of the percentile range. Twenty-three percent of the pilot project population scored on or above the 95th percentile. Another 15 percent scored between the 90th and 94th percentile. A total of 38 percent of the students in the project scored on or above the 90th percentile.

The overall profile of the science test scores was so visibly different from any of the major subject areas that it is reasonable to believe that those pedagogies used in the pilot study had a profound effect on the development of the skills necessary for "doing science." While this pilot study is restrictive, the definitive positive science test scores profile is a strong indicator that the multi-modal approach to learning should have a definite impact on the science programs in our nation's schools.

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TABLE I
Vocabulary

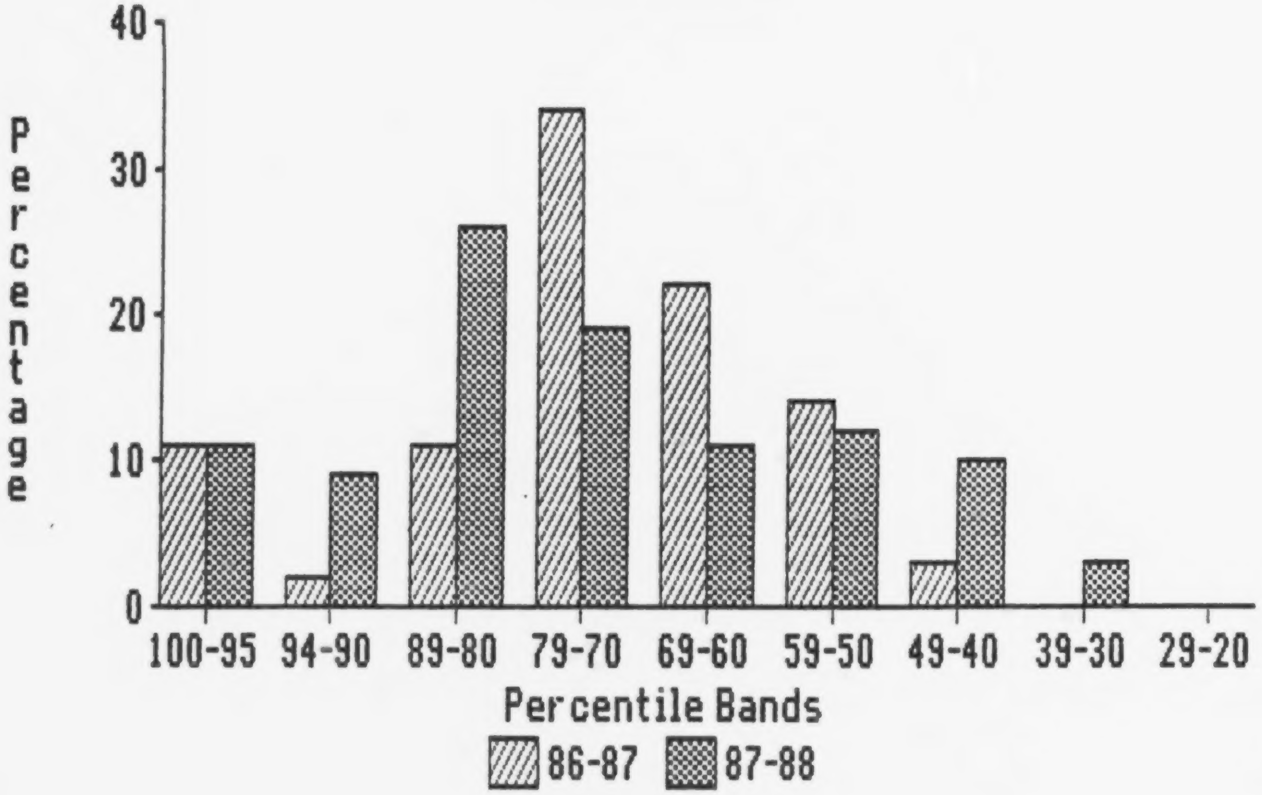


TABLE II
Reading

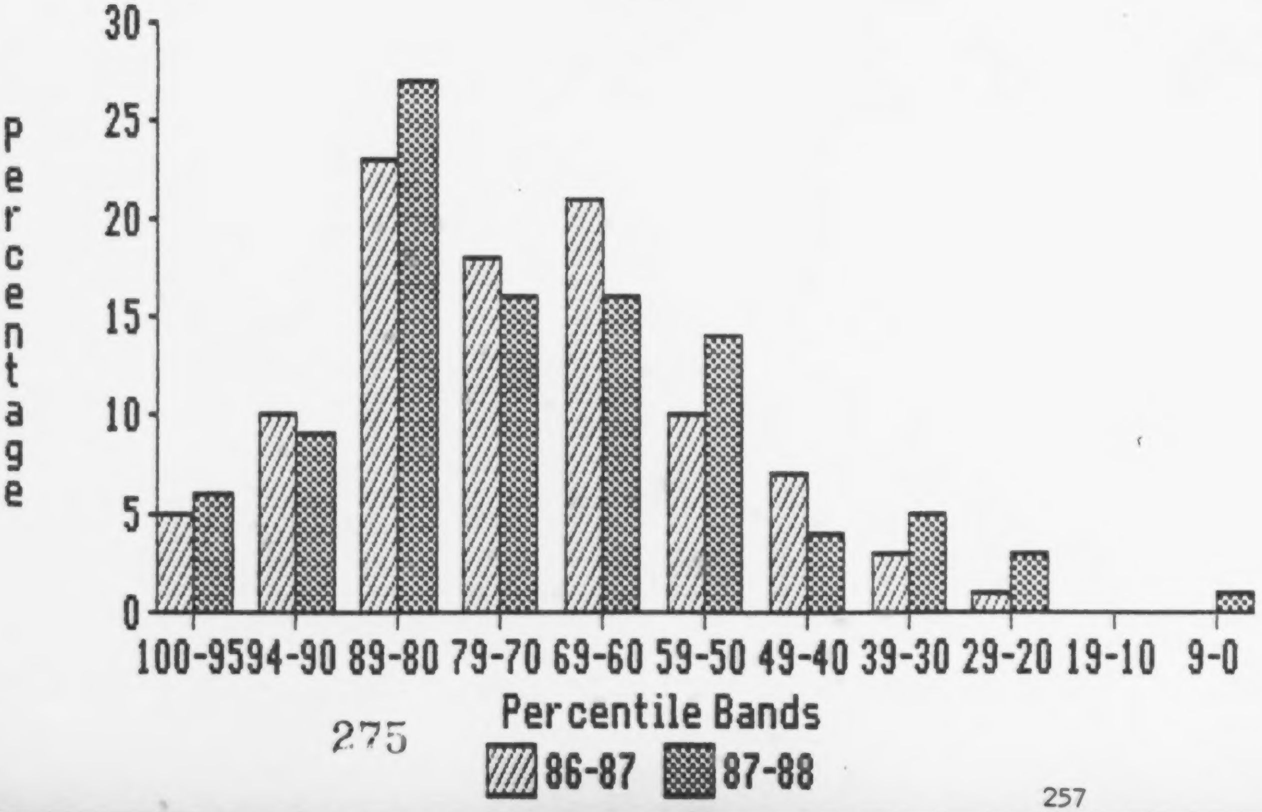


TABLE III
Language Skills

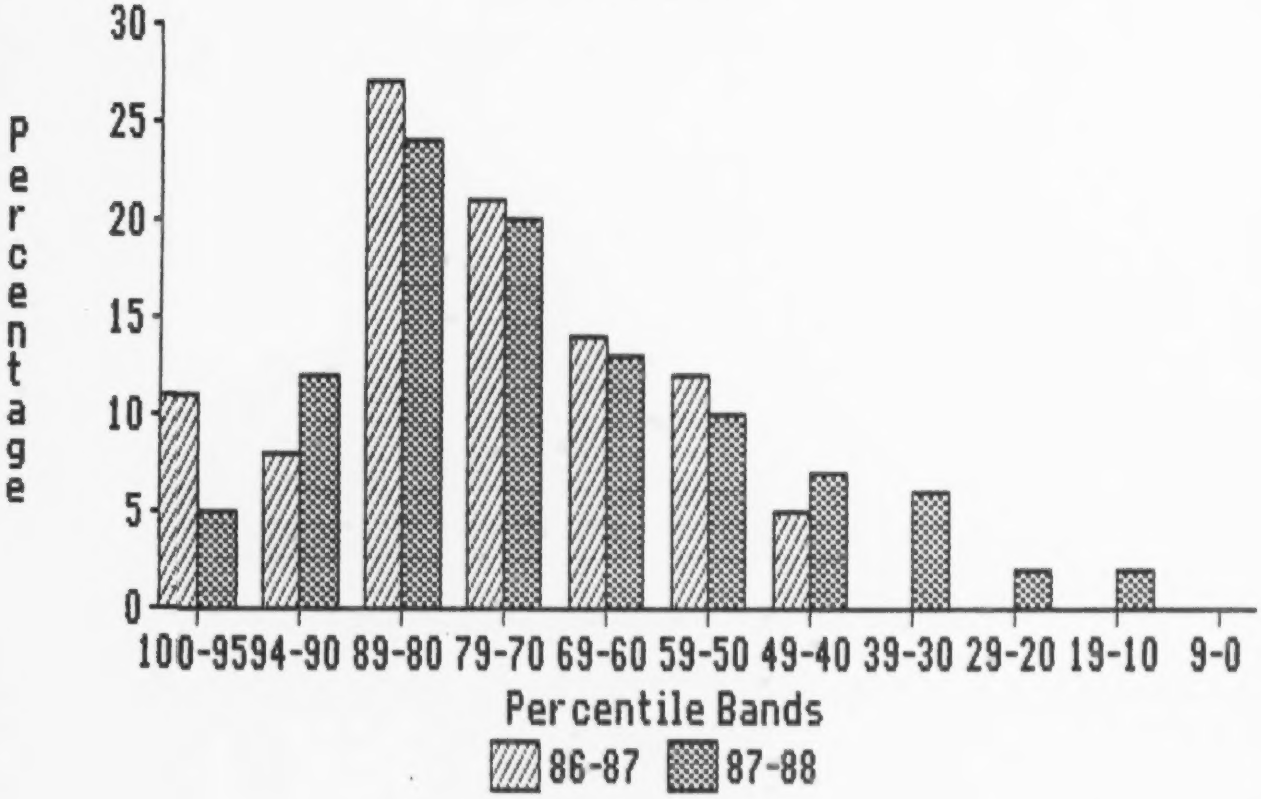


TABLE IV
Work Study Skills

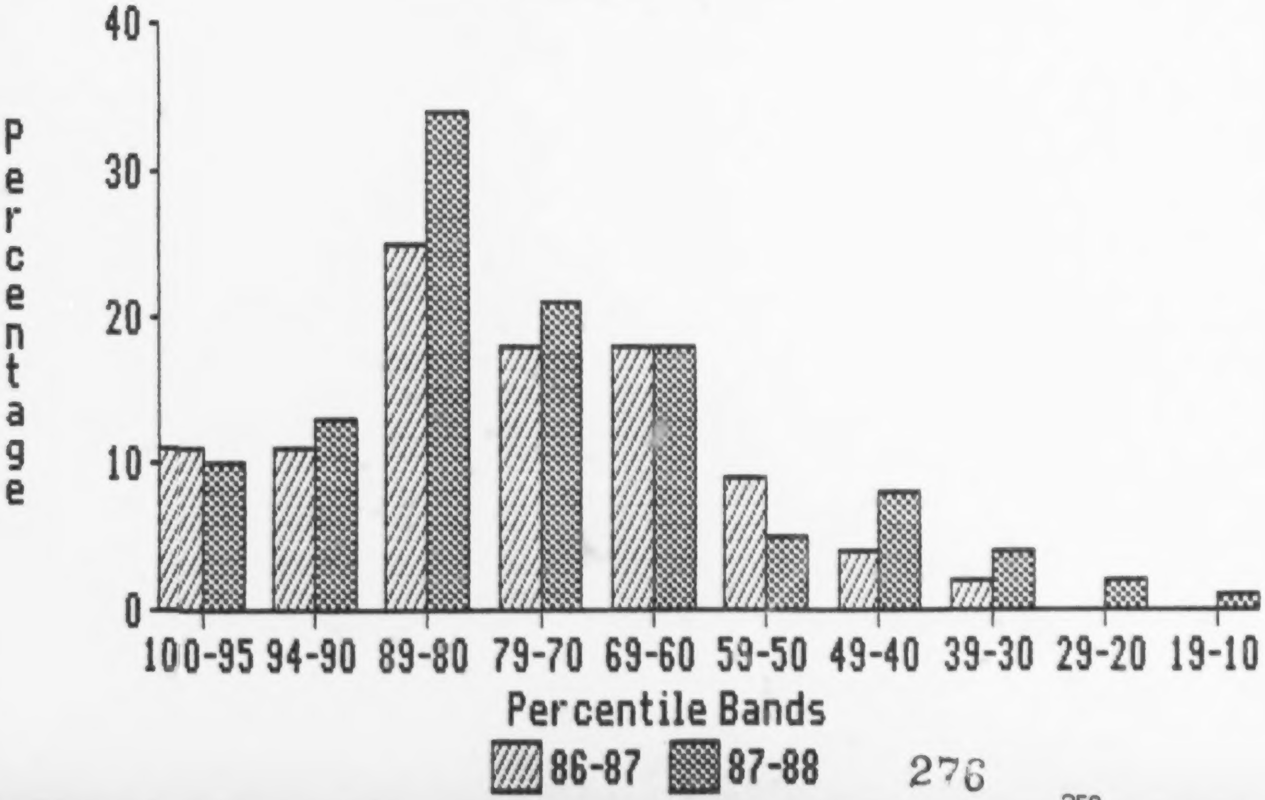


TABLE V
Mathematics

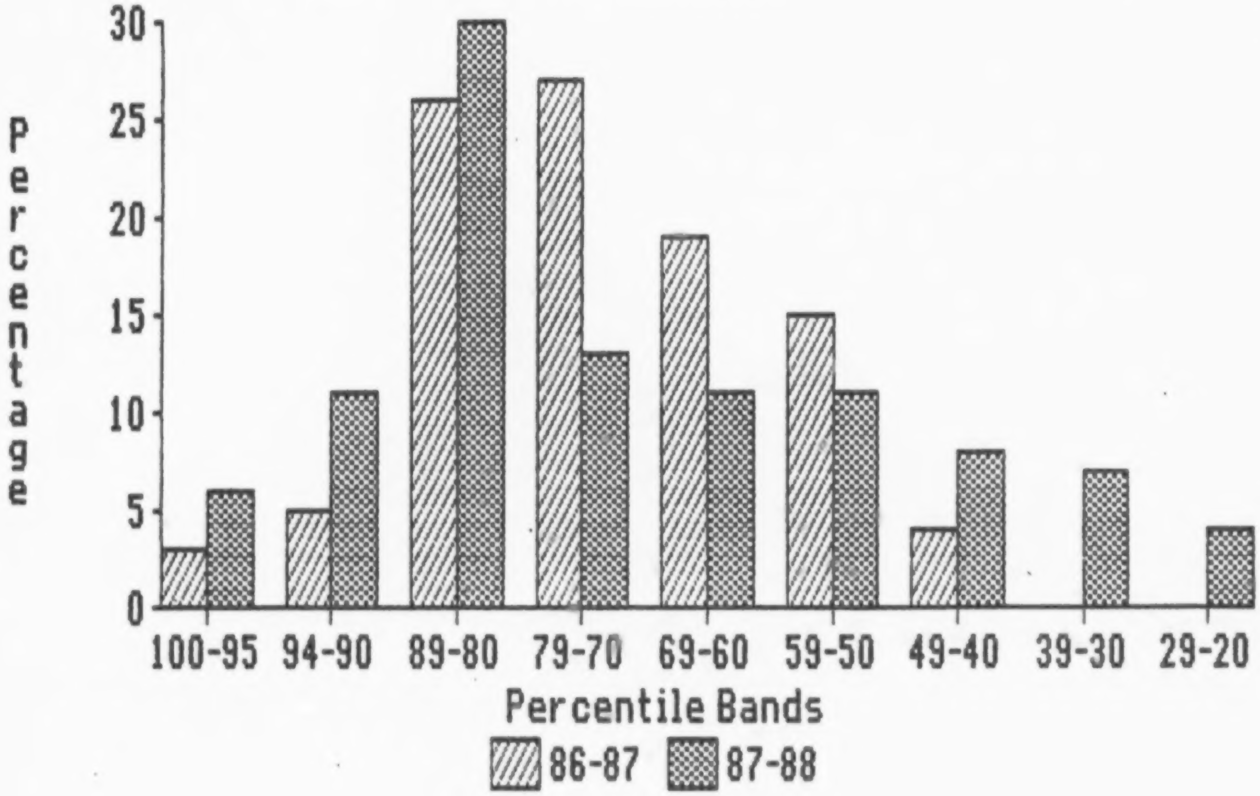


TABLE VI
Science

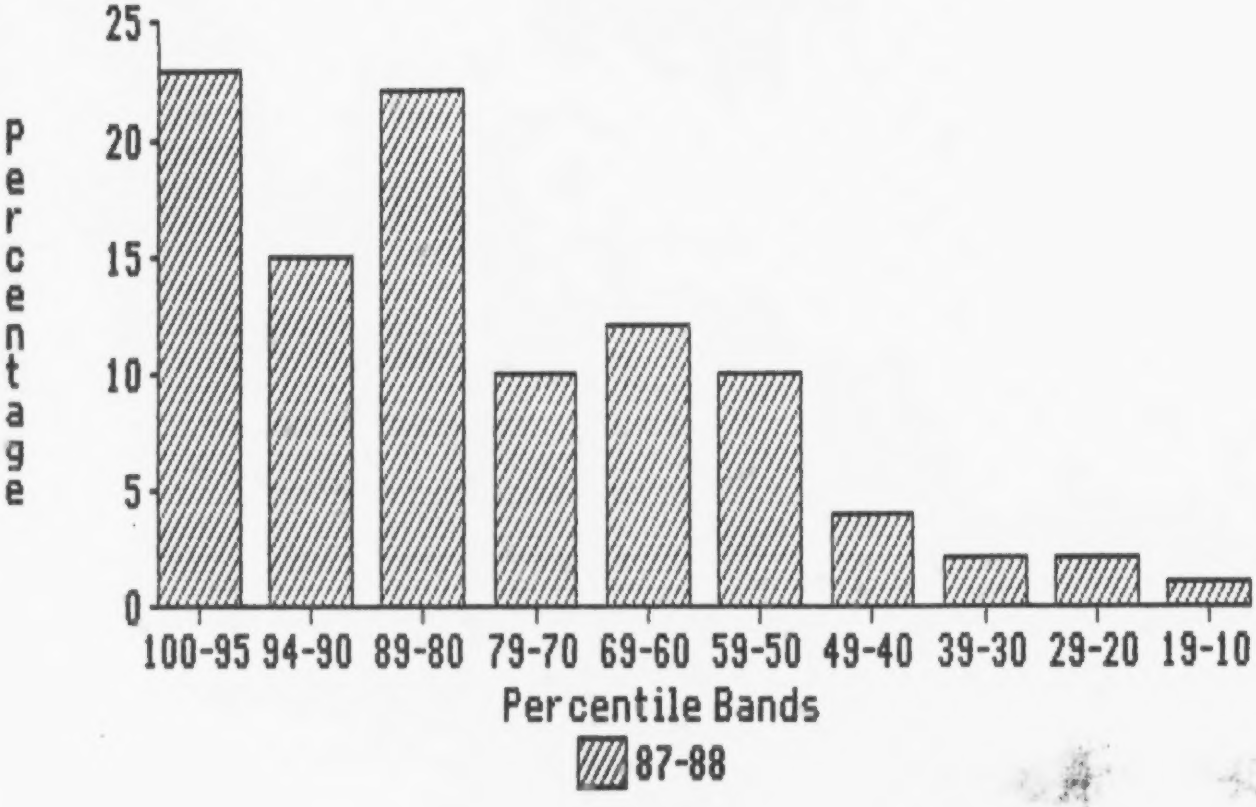
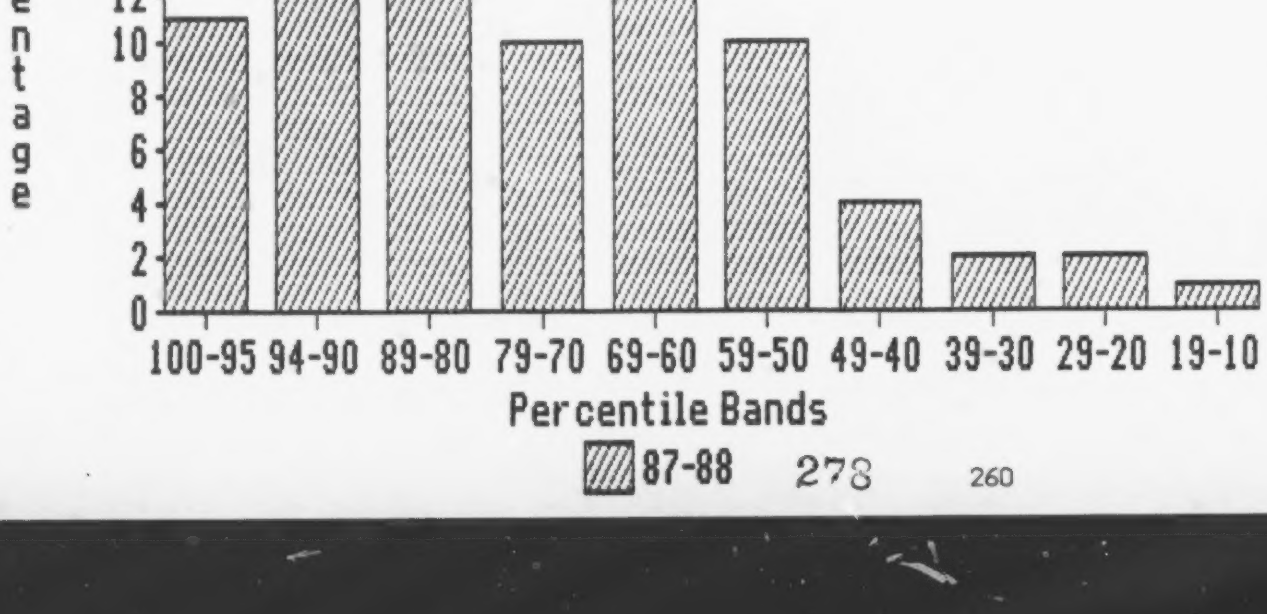


TABLE VII
Social Studies



The Fourth National Science, Technology,
and Society (STS) Conference

Technological Literacy

February 3-5, 1988
Arlington, Virginia

"Curriculum Design Considerations for Technological Literacy"

by

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Curriculum Implications for Technological Literacy

Curriculum Direction

Technology is a major system of society, composed itself of many subsystems. To facilitate the study and understanding of Technology as a system it is appropriate to study its subsystems and then draw these together in an effort to comprehend the whole.

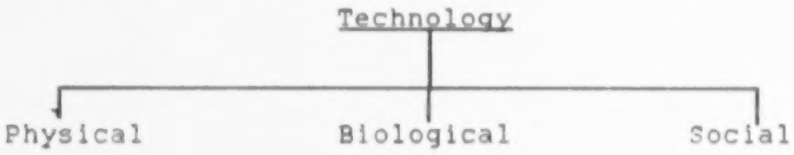
Manufacturing is a subsystem of the physical technology we call Production. The Household (Pure), Handicraft, Basic Factory, Mass Production Factory, and Automation Factory systems are all subsystems of manufacturing which is itself a subsystem of production technology. These manufacturing subsystems function through the interaction of the following imperatives: tools, materials, power, transportation, communication, work, population, institutions, environment. Further, manufacturing is accomplished through two means: fabrication and processing.

Program Rationale

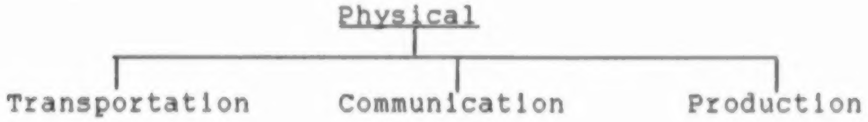
Curriculum Focus

The purpose of general education in the United States is to provide a knowledge base that will enable individuals to meet the many challenges of life. Those knowledge areas of the human, from which content may be drawn for pedagogic purposes are the: Humanities, Sciences, Technologies. This curriculum is specifically concerned with the general knowledge area of Technology.

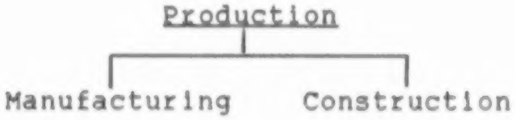
Technology as a term not only implies magnitude, but also complexity. To facilitate the study of technology it is possible to subdivide it in the following manner:



Within the area of the Physical Technologies can be identified three basic human endeavors.



The emphasis of this curriculum model is on "Manufacturing", a subdivision of Production.



Manufacturing is the means by which man produces goods to satisfy not only his basic needs, but also his most superfluous desires. The efforts of man to manufacture needed products can be traced back in history to the very beginning of recorded time. Studies by anthropologists indicate that primitive people were concerned with the manufacturing of goods which were imperative for survival in the hostile environment. Throughout the development of civilization man has continuously applied his intellectual powers to improve upon the important foundational base provided by early man. Through those early beginnings have evolved contemporary techniques and a manufacturing system which now invokes worldwide implications.

Curriculum Assumptions

Upon examining Technology through a manufacturing perspective, it becomes apparent that people play many roles. In our attempt to sustain life, and to begin to fulfill and attain the first faint desires that transcended the basic necessities, attention and interest was directed toward dealing with and enhancing human existence. The ability to solve problems posed by the environment proved to be important to the progressive development of the species. In contending with what must have appeared to be insurmountable hurdles, man became a producer and a consumer of goods and of the natural resources. It was due to the joint participation by many humans in the endeavor of manufacturing that our social nature was further evidenced. The human's role as a problem solver, producer, consumer, and social being continues to the present.

The assumptions of the human upon which this curriculum is based are:

1. Man is a Social Being. As civilization progresses technologically, we will develop an increasing dependency upon our fellow man.

   As we progress from an independent being to a dependent being, we establish social organizational structures, ranging from simple to complex, in order to function.

   Man's social organization is affected by the technical behavioral characteristics of its production system.

2. Man is a Producer. We will utilize our technology in order to satisfy our material wants and needs.

   Our system of production has evolved as an organized way to manufacture material goods.

   We have devised, through his Production evolution, two means of manufacturing goods, fabrication and processing.

3. Man is a Problem Solver. We deal with problems in such areas as social institutions, communication, his physical environment, and his self-actualization.

   We seek to advance through the solution of certain posed technological problems.

4. Man is a Consumer. We will consume our natural resources at a rate proportional to our level of technological development.

   As we progress technologically, the need for more durable and reliable materials will increase.

Major Manufacturing Systems

Listed below are the major manufacturing systems which we as producers have utilized in order to fulfill our material wants and needs. These systems represent man's past, present and future efforts to manufacture goods. Taken together they form a historical and contemporary perspective of ourselves as a creator and user of Technology.

Each system is composed of a number of technical and social cultural elements, or concepts, which depending upon the level of sophistication attained by each imperative determine accumulatively the effectiveness of the system. The study of these concepts in each of the systems is intended to provide the learner with a proper perspective of man's attempts to manufacture products. Major systems to be studied:

--Household (Pure) System of Manufacturing
--Handicraft system of Manufacturing
--Basic Factory System of Manufacturing
--Mass Production Factory System of Manufacturing
--Automation Factory System of Manufacturing

The basic concepts to be studied under each manufacturing system are:

Social/Cultural

- Work
- Population
- Environment
- Institutions

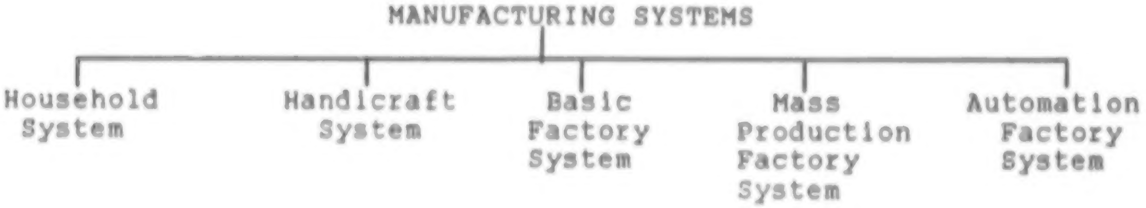
Technical

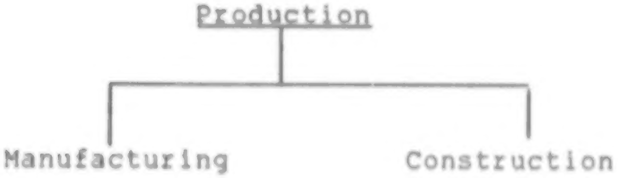
- Tools
- Materials
- Power
- Communication
- Transportation

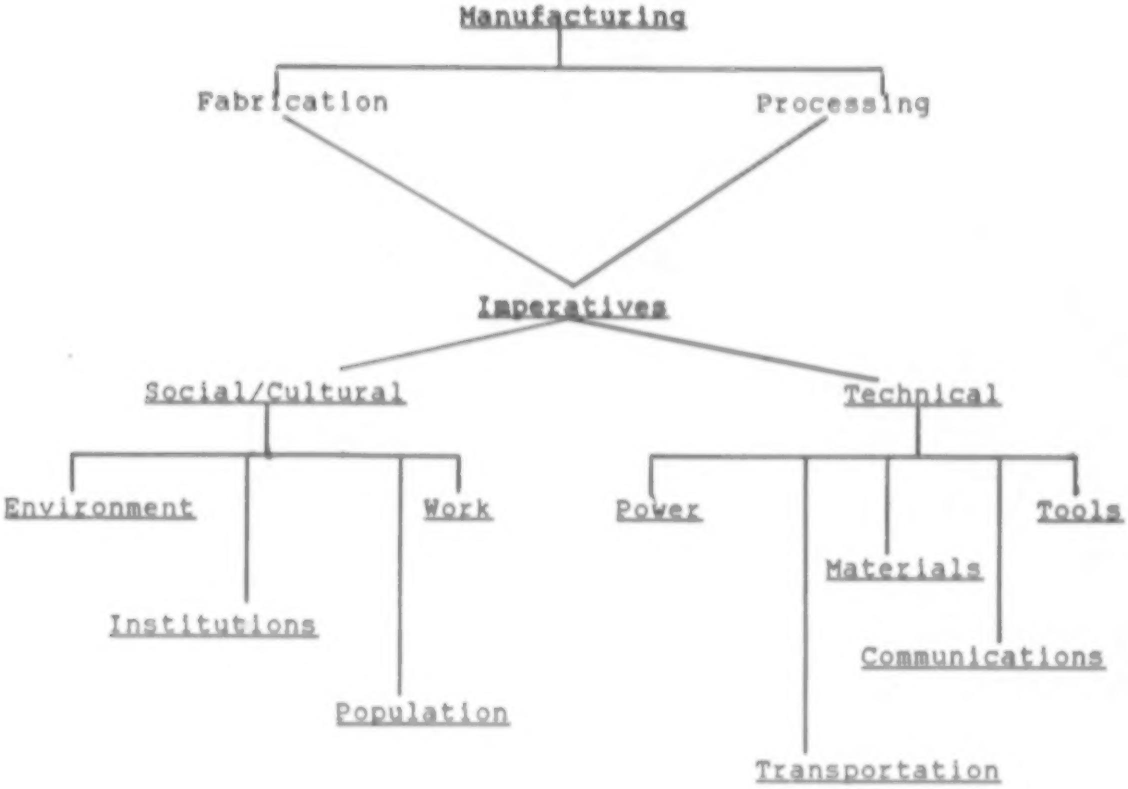
Taxonomic Structure

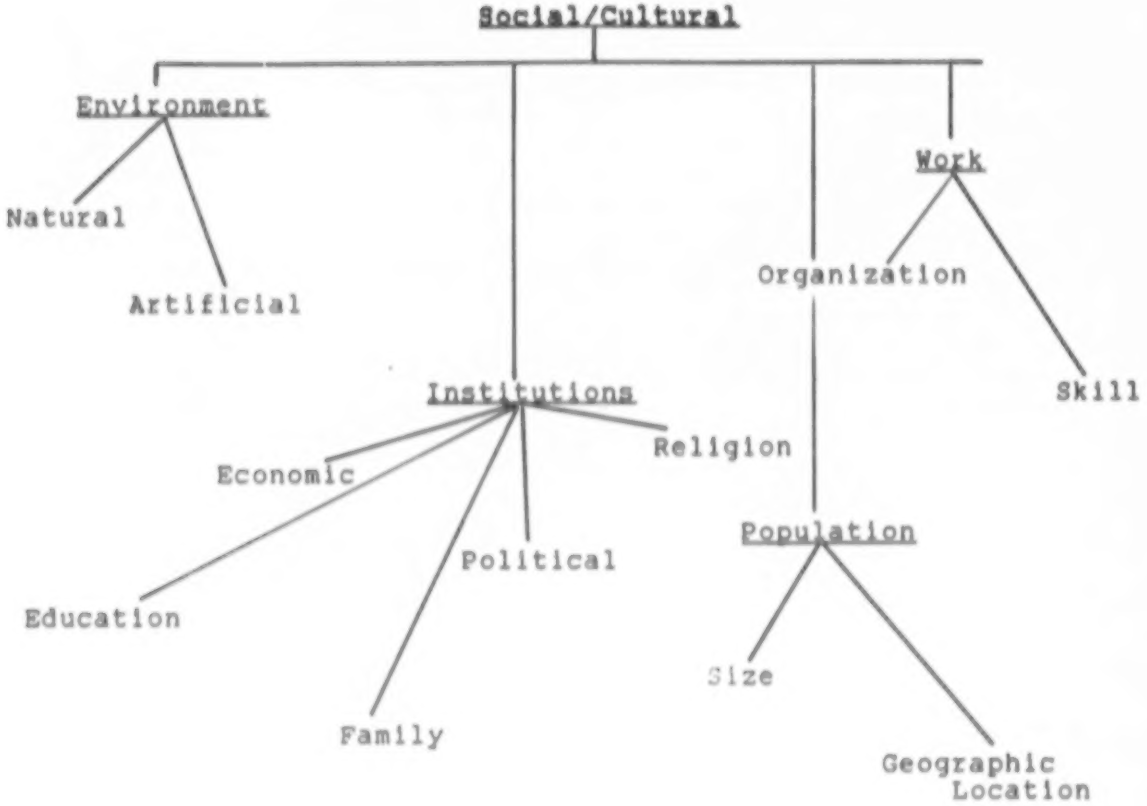
The following structure is a taxonomic representation of the area understudy in this currciulum. Its purpose is to illustrate the interrelatedness between the major manufacturing systems and the concepts which facilitate their study.

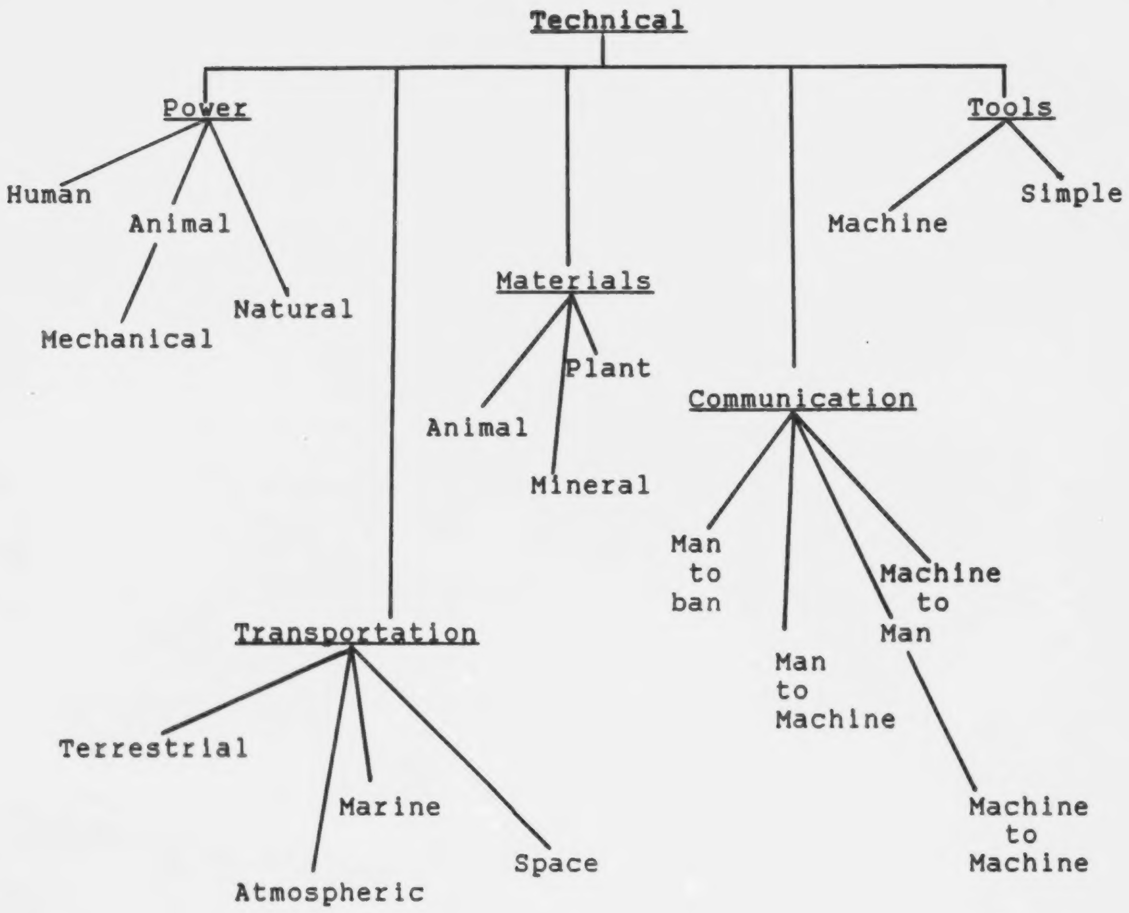
A
HISTORICAL & CONTEMPORARY
PERSPECTIVE
SOCIAL/CULTURAL & TECHNICAL


MANUFACTURING SYSTEMS
Household System
Handicraft System
Basic Factory System
Mass Production Factory System
Automation Factory System


Production
Manufacturing
Construction


Manufacturing
Fabrication
Processing
Imperatives
Social/Cultural
Technical
Environment
Work
Institutions
Population
Power
Tools
Materials
Communications
Transportation


Social/Cultural
Environment
Natural
Artificial
Institutions
Economic
Religion
Education
Political
Family
Organization
Population
Size
Geographic Location
Work
Skill


Technical
Power
Human
Animal
Mechanical
Natural
Transportation
Terrestrial
Marine
Atmospheric
Space
Materials
Plant
Animal
Mineral
Communication
Man to ban
Man to Machine
Machine to Man
Machine to Machine
Tools
Machine
Simple

Instructional Strategy

A four-step instructional strategy can be used to introduce the individual (nine) concepts in each of the five manufacturing systems. This strategy is intended to aid the instructor in the effort to promote conceptual learning within the student.

1. Bring the learner into contact with the concept or attributes representing the concept.
2. Provide the learner with a description or definition of the concept.
3. Allow the learner to come in contact with other examples of the concept, either positive or negative.
4. Afford the learner an opportunity to apply the newly formed concept in a unique and new situation to evaluate his conceptualization.

Systems Overview

An overview of each manufacturing system is provided in the form of conceptual statements pertaining to the nine technical and social/cultural concepts. Taken together these statements form a total perspective of the operational mode of each manufacturing system. Instruction planning may be facilitated through the use of the Conceptual Matrix.

Household System Conceptual Statements

System: When the forms or types of manufacturing are arranged in developmental order, it is the Household (Pure) System that comes first.

Tools: Whenever objects are manufactured in the Household (Pure) system, it is done so through the exclusive use of basic wrought iron and wooden hand tools.

Materials: When operating in the Household (Pure) System of manufacturing, wood, iron, and bronze are the principle basic raw materials used in the making of products.

Power: When in the Household (Pure) system of manufacturing the major sources of power is supplied by man or animal.

Transportation: When the transportation of raw materials or finished products is accomplished through the use of dirt roads and/or natural waterways the Household (Pure) system is in use.

Communication: When in the Household (Pure) system word of mouth and written messages facilitate the communication necessary for manufacturing.

Population: Whenever manufacturing is carried out in the Household (Pure) system it is concerned with satisfying the needs of the individual family members.

Work: Work, when done in the Household (Pure) system of manufacturing, is comprised of all around skilled craftsmen and unskilled manual workers.

Institutions: When the Household (Pure) System exists it is the family that determines the significance of each social institution.

Environment: Products, when manufactured in the Household (Pure) system, are influenced by the natural environment in which they are found.

Handicraft System Conceptual Statements

System: When the forms or types of manufacturing are arranged in developmental order, it is the Handicraft system that comes second.

Tools: Hand tools supplemented by simple hand operated and controlled machines are employed whenever the Handicraft system of manufacturing is in use.

Materials: When operating in the Handicraft System of manufacturing extracted and harvested materials such as wood, iron, bronze, and wool are utilized as the basic raw materials.

Power: Whenever the handicraft system is functioning, the application of water and wind power contribute significantly to the manufacturing of products.

Transportation: When the Handicraft system exists, manufacturers utilize a system of roads and man-made canals for transporting raw materials and finished products.

Communication: When the Handicraft system exists, verbal and written descriptions, accompanied by models of the products, are the forms of communication that facilitate the manufacturing process.

Population: When prevailing individualized production and consumption requirements no longer meet the needs of an increase in population, the Handicraft System is applied.

Work: Specialized skilled craftsmen and a functional division of labor are employed whenever the handicraft system of manufacturing is used.

Institutions: When the Handicraft system of manufacturing is established, social and labor organizations emerge.

Environment: When the Handicraft System of manufacturing is used, there is a decided effort by man to better deal with the environment.

Basic Factory System Conceptual Statements

System: When the forms or types of manufacturing are arranged in developmental order, it is the Basic Factory system that comes third.

Tools: When powered machines of wrought iron and steel are operated by single individuals within the confines of a factory, then the Basic Factory system is in evidence.

Materials: When improved methods of extraction, smelting, and refining of raw materials evolves, steel emerges as the primary material of the Basic Factory System.

Power: Whenever the Basic Factory system functions, the steam engine provides the primary source of power in the manufacturing of products.

Transportation: When steam trains and/or ships facilitate the movement of raw materials and products, the Basic Factory system is the predominant means of manufacture.

Communication: Mechanical drawings and models of products constitute the means of communication when in the Basic Factory System.

Population: When the Basic Factory system is the dominant means of manufacture, there is an increase in population and a migration of laborers to city dwellings.

Work: Semiskilled laborers, under supervision, operating power driven machines resulting from subdivided manufacturing processes, compose the work force when the Basic Factory System is in use.

Institutions: When the Basic Factory System develops as the means of manufacture, the economic system begins to gain influence over the other institutions.

Environment: When the Basic Factory system is in use, artificial environments are constructed to enhance the manufacturing process.

Mass Production Factory System Conceptual Statements

System: When the forms or types of manufacturing are arranged in developmental order, it is the Mass Production Factory system that comes fourth

Tools: When the Mass Production Factory system exists, the tools which are utilized in the manufacturing process are multiple machine tools and automatic machines.

Materials: When in the Mass Production Factory system alloyed metals and synthetic materials are found to be the dominant substances from which manufactured goods are produced.

Power: Whenever electricity is utilized as the predominant source of power for production, the Mass Production Factory System is found to exist.

Transportation: Paved highways, airways, shipping lanes, and railways serve to transport raw materials and finished products when in the Mass Production Factory System.

Communication: When the Mass Production Factory System is in operation, production drawings form the communication media.

Population: When there is a large suburban population commuting between areas of residence and centers of employment, the Mass Production Factory System exists.

Work: A highly developed division of labor composed of management and labor groups facilitate production when in the Mass Production Factory System.

Institutions: When the basic institutions of man are altered and influenced on a universal scale to accommodate manufacturing, the Mass Production Factory System is in operation.

Environment: When the natural environment is altered to accommodate the manufacturing of products, the Mass Production Factory System is found.

Automation Factory System Conceptual Statements

System: When the forms or types of manufacturing are arranged in developmental order, it is the Automation Factory System that comes fifth.

Tools: When the Automation Factory System is in use, computer controlled automatic machine tools are employed exclusively.

Materials: When the Automation Factory System is functioning, plastics, super alloys, new metals such as magnesium and titanium are found to be the dominant materials for the manufacture of goods.

Power: Whenever the Automation Factory System occurs, the application of atomic energy contributes to the manufacturing process.

Transportation: When computer assisted terrestrial, atmospheric, space, and marine vehicles serve to transport raw materials and finished products, the automation Factory system is found to be the principle means of manufacture.

Communication: when the automation Factory system is in operation, computer graphics contribute to the communication necessary for manufacturing.

Population: When the Automation Factory System exists, human involvement in manufacturing moves from an industrial to a post-industrial state.

Work: Skilled technicians required for maintenance, and highly trained engineers who function as designers are employed when the automation Factory system is in operation.

Institutions: When the Automation Factory System exists, the basic institutions of man function as a universal network.

Environment: Whenever the Automation Factory System occurs, the manufacturing process is performed in a totally controlled artificial environment.

CONCLUSION

The "curriculum design considerations" which have been outlined in this work may be helpful in guiding program efforts toward a more comprehensive curriculum, one which accommodates "Technology Literacy". Taken together these elements are not ends in themselves, rather they are means to an educational process which emphasizes Technology and Curriculum Development/ Implementation. The model which has been described in this work is not offered as anything else but one attempt toward accommodating the need for Technology Literacy. Its merits is seen only in this manner; that until educators acknowledge the worth of understanding Technology and address all areas of curriculum and instruction the educational programs now in place will continue to fall short.

Science Technology and Society:
The Iowa Chautauqua Model for Inservice Teacher Training

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Introduction

Science educators throughout Iowa are developing issue-based programs as part of a workshop series designed to engage inservice teachers with the ideas necessary to involve students in activities which illustrate the relationship of science, technology and society. Support for this endeavor has come from a unique partnership between the Iowa Utility Association which sponsors the Iowa Chautauqua Program in cooperation with the Science Education Center at the University of Iowa. This outreach teacher inservice program which has been operating since 1985 as a partnership between business and education is proud of its pioneering efforts in setting a new direction for science education.

The goal of the Chautauqua STS inservice workshops is to assist teachers as they develop an issue-based teaching strategy. Such strategies are vital if students are to understand how science, technology and society influence one another both in the creation and in the solution of many current problems.

The Iowa Inservice Model

The workshop model itself consists of a two day workshop on a Friday and Saturday in the Fall with a similar follow-up session in the Spring. This year over 200 teachers participated in the weekend sessions held at five different sites throughout Iowa during the academic year. In the Fall, participants are introduced to the STS philosophy as they explore examples of a variety of appropriate teaching strategies. The principal teaching technique used during the Fall session is an exercise modeling the issue-based teaching philosophy central to the STS philosophy. The activity, described later in this paper, illustrates how to use local issues as module organizes to introduce the STS conncetion for students in the classroom and beyond.

STS curriculum strands are identified and the participants develop an initial plan for a 20-day module designed to draw connections between science, technology and society. In addition to the idea-sharing that occurs between teachers as they begin work on their modules, presentations are made to assist in the process of locating pertinent resources from both local and national sources. A rationale for evaluation of students, and the methods used to assess the successes of STS teaching efforts are discussed; sample instruments are provided.

When teachers return in the Spring they share the outcomes of their STS teaching experiences and report on their research efforts. At the completion of the workshop the participants receive three graduate credits from the University of Iowa, but in addition, they have gained a new science teaching philosophy based on real world issues and problems to share with students.

Using Local Issues As STS Module Organizers

The fundamental purpose of the Iowa Chautauqua Program is to assist teachers in the development of STS modules for use in their classrooms. These modules incorporate many of the teaching strategies used by teachers in the past, but are organized around local issues. This is a significant departure from the traditional approach for most. The following procedure is one suggested method for module development which has been successfully used by hundreds of teachers, at all grade levels, over the past four years. The development process is modeled by the Chautauqua staff as part of the inservice workshop.

The starting point for the development of any STS unit is the identification of a problem, or issue. The issue for investigation is selected by the students and the teacher based on the students' questions. Teachers report that in just a few short minutes students are frequently able to identify a lengthy list of problems that may need further investigation. Through a process of selection, the class arrives at the issue which will form the basis of the unit. Issues selected in the past have covered a wide range of topics including acid rain, local landfill sites, school lunch problems, leaky faucets, high energy bills, and declining wildlife habitats. Whatever the issue, it should be clearly viewed by the students who will be involved in the investigation as both relevant and meaningful.

After the issue has been selected, some potential directions of study are identified. A student brainstorming exercise will very quickly produce a list of concerns and questions which are then organized by subtopics. Students working in small groups take a subtopic and generate additional questions related to their areas of interest.

At this point, a problem has been identified and some initial directions for investigation have been defined. Students, now seeing the need for resources and information, begin to seek out answers to their own questions. The information-gathering phase of the investigation may take many forms including library research, contacting a community member or business person, writing to a governmental agency, experimenting, or constructing a model for study. As the investigation continues, information is constantly shared with the entire class through group presentations and guest speakers.

As the investigation of the issue proceeds, new questions and directions for study are continually identified. Students are actively pursing areas of interest, while realizing the relationships between technology, science, and society. Science concepts emerge as meaningful components of the process because they are necessary to understand the complex problem under investigation. The need to know certain information extends from the students, rather than from the teacher or textbook. Many teachers report that their students encounter far more science content during an STS investigation than they would have during a traditional unit organized around facts and information. Not all chosen issues are fully resolved at the conclusion of the unit, but the STS philosophy is based as much on process as it is on product.

The Role of Assessment in the Iowa Chautauqua Program

Science, Technology and Society, and other issue-based programs, have the potential to assist students in visualizing a full picture of the nature of science, but traditionally our assessment of students in these programs has been limited to areas of knowledge acquisition alone. With the development and introduction of a multidimensional assessment model it is possible to measure student progress within various dimensions of science education and gain a more complete view of each student.

The Iowa Package for Evaluation in Five Domains of Science Education was developed in cooperation with participants in STS workshops to provide the tools necessary to assess students more completely. The nature of science is so complex that examination instruments have been designed to focus on each of five broad regions or domains within the discipline. The specific areas chosen for examination reflect the arena in which scientists actually work and include the perceptions of science by society. In addition to scientific **knowledge and information**, the domains include the **application** of that knowledge, the **processes** and **creativity** employed by scientists as they investigate the world, and the **attitudes** which represent public and student reactions to science and science education.

The role of assessment in the Iowa Chautauqua Program is two-fold. We hope to persuade participants in the workshops that a more holistic assessment of students is a valuable endeavor, while providing suggestions for tools to be used in developing a more wide ranging assessment scheme. It is a sincere hope that teachers will continue to move toward a more complete assessment protocol in their future interactions with students as a result of their exposure within the workshops. A secondary goal is to use the assessment program to provide data for the evaluation of the effectiveness of the STS philosophy in increasing student achievement within the target areas. In moving toward this second goal, a pilot study was conducted during the 1987-88 workshops. Participants were asked to design and/or select and administer appropriate assessment instruments before and after their own issue-based module and provide results to the workshop organizers. As a result of enthusiastic participation much valuable information has been gained permitting many exciting inferences.

In the cognitive areas we found on the teacher-designed tests of knowledge and information average gains of achievement of 33 percentage points with high statistical significance in 97% of the cases. There was an average gain from pretest to posttest of 9 percentage points on teacher-made tests of application of science concepts with significance 63% of the time. On a process skills test provided to the participants, students made an average 7 point gain, with 52% of the increases demonstrating statistical significance.

We used several measures to indicate aspects of creative thinking in an attempt to ascertain the most effective tool for assessment in this area. Preliminary results from one instrument show that the mean number of responses made by students to an unusual situation grew from 12.31 per student before the S/T/S module to 15.58 after such instruction. This is the result one would expect in cases where the nature of the module or the method of instruction fostered divergent and creative thinking.

Finally, a measure of student attitudes about science, technology, and science instruction illustrated that in most cases attitudes remained unchanged. This in direct contrast to recent national studies showing increasingly negative attitudes the longer students study science. Of the approximately 20% of the items which did display change, students seemed increasingly more positive when asked questions about the usefulness of science information outside of school, the applicability to science class to future careers, the place of technology in daily living, and basic feelings about their experiences with school science.

Conclusions

The Chautauqua STS inservice model has thus far helped over 600 teachers in the state of Iowa experience a teaching philosophy with relevance as its keystone. Designed to assist teachers in developing STS curricula that are both issue-based and student centered, these workshops have been received positively and enthusiastically by teachers as well as administrators. As the full impact of the program is realized more school and district teams will become involved as teachers and their students benefit. The Iowa Chautauqua Program exemplifies an Iowa Alliance for Improved Science Education, and has been recognized by Governor Terry E. Branstad as a model program for teacher inservice.

The Chautauqua teachers are pilot-testing STS modules as they form a network of educators concerned about science education. Our efforts in establishing a bond of support between education and industry, as well as the design of an effective inservice program, is making a real difference in helping students and their teachers see the connections between science, technology and our society.

STS THEMATIC UNIT DEVELOPMENT

by

Frederick A. Staley

Thematic units can be used as one approach for infusing STS into the existing science curriculum as well as a model for the creating an entire course with an STS emphasis. While this is written as a guide for elementary and middle school teachers to create thematic units, it can serve as a resource for high school and university instructors as well.

WHAT IS A THEMATIC UNIT?. A Thematic Unit is a segment of curriculum organized around a central idea or theme. Thematic units often emphasize the integrated nature of disciplines, having the potential to combine language arts, reading, literature, social studies, mathematics or the fine arts with science instruction. Because of this potential for integrating disciplines, thematic units are ideal for STS topics, issues and problems which, by their vary nature, must be studied in an integrated fashion.

WHY THEMATIC UNITS? Creation of thematic units provides one very good way of putting the teacher, not the textbook author or publisher, in a position to make important decisions about curriculum, learning and instruction. It is the teacher, after all, who is the trained professional who can combine knowledge of learning and development theories with knowledge of specific science concepts, skills and attitudes in creating meaningful curriculum. Furthermore, it is the classroom teacher who knows the backgrounds, needs and topics of current interest of their students. It is also the teacher who knows the unique instructional resources of the classroom, school, community and state. While thematic units do not replace state or district guidelines, they do allow for the organization of the content of these guidelines into manageable, meaningful and exciting learning opportunities for students. Thematic units which integrate disciplines provide a mechanism for getting science into the class day, which, for many elementary school teachers at least, is a near impossibility when science is to be taught as an isolated subject.

WHY NOT TEXTBOOKS AS THE MAIN SOURCE OF CURRICULUM? All science textbooks suffer from one major limitation: they are textbooks. In other words, with textbooks the intended format is usually to have students read the book, view an occassional demonstration or conduct a laboratory activity, answer questions at the end of the chapter and take tests over the text material. This is not real science and does little to accomplish the role science or STS ought to be playing in helping students to become scientifically and technologically literate citizens. Using textbooks as the main source of curriculum in the way just described has these serious limitations:

1. Textbooks do not take into account the local environment and resources that are readily available to teachers.
2. Textbooks do not take into account the needs and interests of the students and teachers in a specific classroom.
3. Textbooks do not take into account current events or locally determined issues and problems.

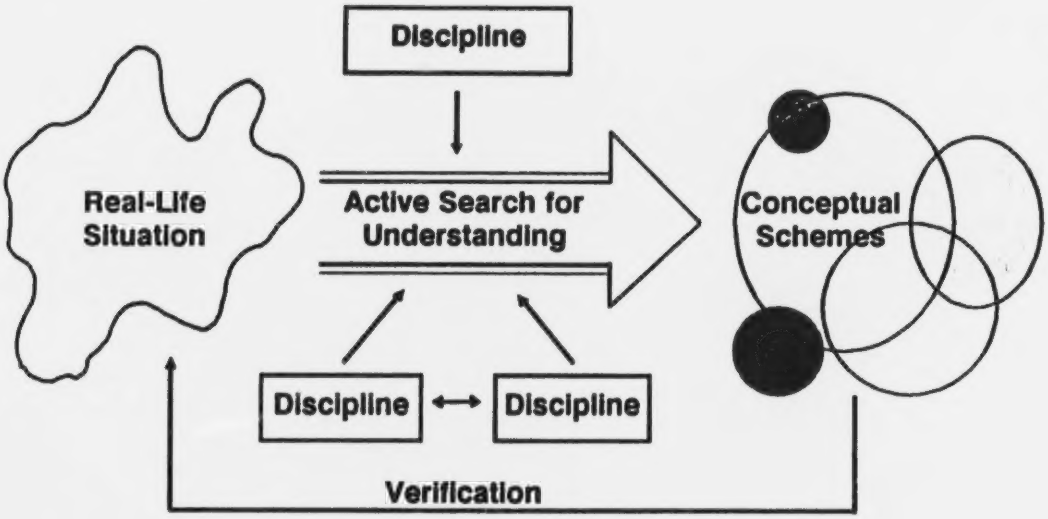
4. Textbooks attempt to present information on too many concepts and topics in their attempt to provide a balance of life, physical and earth science. The total number of pages given any one topic rarely exceeds 10 pages.

5. Since a good number of students in today's classrooms have difficulty with the reading process, having them attempt to learn science through this approach is all too often counterproductive. In addition, when faced with teaching science with a textbook as the central source, all too often the science lesson becomes another reading exercise.

Consequently, if teachers feel inadequate in science or STS, the presentation of information on many different science content areas and STS topics, issues and problems, makes it necessary for the teacher to depend upon the text and accompanying worksheets for their science program. On the other hand, when teachers create their own or use thematic units created by other teachers, textbooks can serve as resources of ideas and information for both teacher and students. Textbooks need not be used, however, to determine the total scope and sequence of the science curriculum.

THEMAITC UNITS AS AN INSTRUCTIONAL VEHICLE. Hickman's (1984) Real-Life Situation Curriculum Model describes a curricular framework which is appropriate for developing citizens for a future which will be more scientifically and technologically oriented. The model also serves as a framework for thematic unit development. Thematic units, Hickman would suggest, ought to focus on real-life situations. Instead of dealing, then, with slices of many different disciplines (as textbooks often do), a teacher and students can deal with slices of life (as shown below in Figure 1), using the disciplines to illuminate, not to obscure, learning.

Figure 1



Hickman's Real-Life Situations Model

In this model real-life topics, issues and problems which are relevant and meaningful for the students serve as the themes for instructional units, rather than the physical-chemical, life-health or earth-space discipline-bound topics which typically serve as the organizers for science curricula. As a theme is investigated many disciplines are drawn upon to help understand the topic and to express this understanding in some form. While these investigations are going on, process skills, problem finding, problem solving and decision making skills are emphasized. Finally, it is important that all this searching for understanding lead to the acquisition of conceptual frameworks which help students understand the big picuture of scientific, technological and social interaction involved with the theme under study. The student can then use these conceptual schemes as tools in the study of other thematic units.

When appropriately created and used, thematic units provide the big picture, curriculum wise, and assist students in long term memory and the acquisition of life long skills. Real-life situation topics, issues and problems provide a context for students to understand and classify how everything is interrelated. Thematic units, furthermore, encourage students to participate and then to actually integrate what they learn into their everyday lives. A theme creates the context for what is to follow and provides a structure around which the mind can organize information into meaningful wholes.

STATING AND IDENTIFYING REAL-LIFE SITUATION THEME CATEGORIES. While there are many ways to categorize themes, one approach which fits well with the Hickman model presented above is to think of themes as being either topics, issues or problems. Definitions and examples of each of these three types of themes are as follows:

1. A TOPIC - stated as a word or phrase which is a label for a natural or human-made phenomena (an event, place, organism, technology, structure, organization) serving as the focus of study. This type of unit helps students understand more about the phenonema under study while learning processes and concepts which can be applied to understanding other real-life situations topics.

EXAMPLES: The Sonoran Desert, Robots in our Society, Photovoltaics as an Alternative Energy Device, Animals in Our School Zoo.

2. AN ISSUE - often stated as a declarative statement or question to which individuals or groups can take sides; a point in question or matter that is in dispute with two or more views. The purpose of this type of unit is for students to understand the issue, to determine the different points of view, to identify the value orientations and arguments of those espousing different views, to perhaps take a position on the issue and finally to act on the basis of this position.

EXAMPLES: Constructing dams is a primary way to control flooding in our city, Nuclear power plants provide a legitimate energy alternative, Should any type of non-human animal be used in biological and medical research and experimentation? Which would you rather have at the grocery check-out stand: Plastic or Paper?

3. A PROBLEM - stated as a question which asks about a matter of concern involving doubt, uncertainty or difficulty. The purpose of this type of unit is for students to understand the problem, develop alternative solutions and finally to act on the basis of the solutions they choose. It should be pointed out that while most people might agree that something is a problem, there may be many different issues or points of view involved with how the problem can and should be solved. Thus, starting with a Problem Theme may also involve many Issues.

EXAMPLES: What are the causes of the holes in the Ozone layer and what can be done to help? What impact is Urban Sprawl having on our quality of life and what can we do about it? What are the causes of World Hunger and what can be done to help eliminate hunger in the world? What can we do at school to decrease the amount of energy we use?

OTHER THEME CATEGORIES. Two other theme categories which are frequently used are CONCEPT and PROCESS themes. Notice that both Concepts and Processes are ingredients of the Hickman model. They can, therefore, be used as the starting point for thematic unit development and, if real-life examples are used to help teach the concepts and/or processes, the end result might be the same as starting with a real-life topic, issues or problem. The use of Process or Concept Themes can be justified when a teacher decides such an emphasis would provide foundational understandings and skills necessary to experience future Topic, Issue or Problem Themes. These two additional theme categories are defined as follows:

1. A CONCEPT - ideas that can be stated as a single word or phrase. Concepts define or give attributes of ideas, objects, systems or situations.

EXAMPLES: Change, Interaction, Energy, Death, Birth, Community, System, Organism and Object

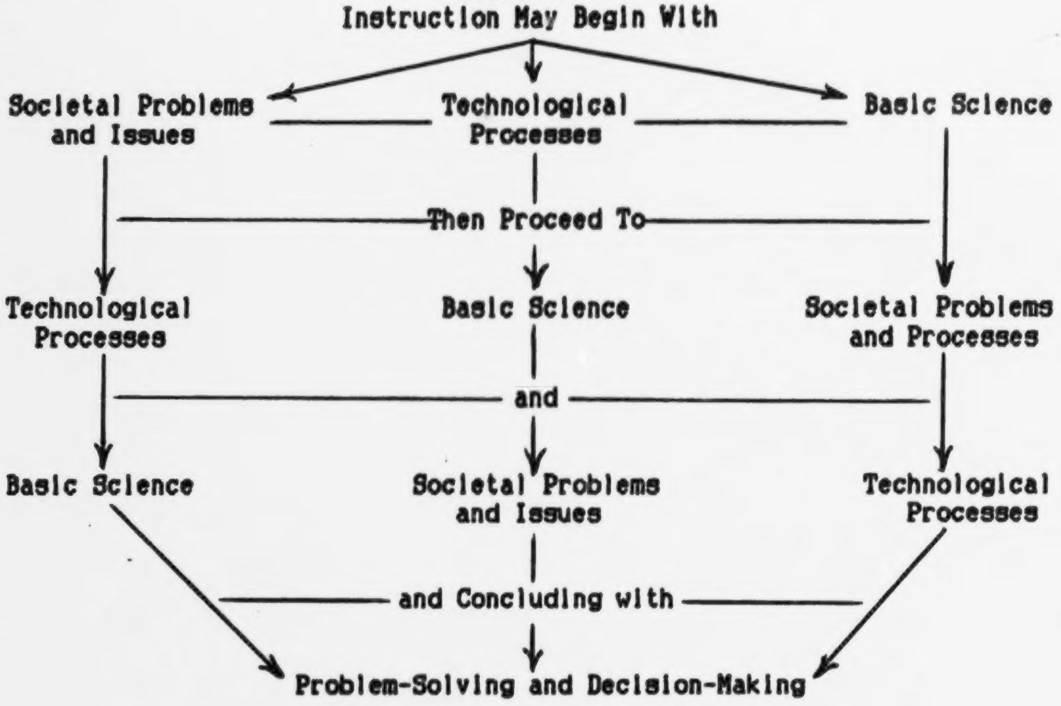
2. A PROCESS - intellectual skills that can be expressed in a single word or phrase.

EXAMPLES: Observing, Predicting, Hypothesizing, Fantasizing, Communicating, Controlling Variables and Experimenting

ANOTHER MODEL FOR THEMATIC UNIT DEVELOPMENT. Topic, issue, problem, concept and process categories are all different ways of organizing activities for the creation of thematic units. The Real-Life Situation Model of Instruction provides one good approach to the creation of thematic units especially designed with a Science, Technology and Society (STS) emphasis. The STS Instructional Model developed for the State of New York (1986), shown in Figure 2, provides yet another good model for the creation of thematic units. Note, the New York Model suggests three possible starting points which overlap with the three facets of the Real-Life Situation Model: i.e., Societal Problems or Issues (Issue or Problem Themes), Technological Processes (Process Theme), or Basic Science (Concept Theme).

As you proceed toward decision making and solving a problem at the completion of the unit, all three components of the model are incorporated.

Figure 2


Instruction May Begin With
Societal Problems and Issues
Technological Processes
Basic Science
Then Proceed To
Technological Processes
Basic Science
Societal Problems and Processes
and
Basic Science
Societal Problems and Issues
Technological Processes
and Concluding with
Problem-Solving and Decision-Making

State of New York STS Instructional Model

DISADVANTAGE OF THEMATIC UNITS. There is one major disadvantage to thematic unit development. It takes a great deal of time and a great knowledge of resources (people, places and curriculum materials) to create good thematic units. Fortunately, this disadvantage can be overcome by many different strategies. One strategy is for teachers to attempt to create, implement and improve only one or two thematic units a year. The rest of the time commercial programs may serve as the basis for the science curriculum. In time, teachers consistently writing and using thematic units will have created and revised several useful units.

A second strategy is for teachers to share units. This not only multiplies the number of units each teacher has at their disposal but it also provides an important team planning approach to curriculum development. Thus, much pertinent knowledge about children and curriculum is shared by concerned teachers.

A final strategy that simplifies the process of creating thematic units consists of incorporating ideas and activities from existing commercially or locally prepared materials into broader units. The skill of doing this not only requires a thorough knowledge of what is contained in the commercial materials but also requires the ability to sequence these activities into meaningful whole units.

SUGGESTED TWELVE STEPS TO THEMATIC UNIT DEVELOPMENT. The remainder of this article will attempt to provide some insight into the process of thematic unit curriculum development. The steps suggested here have proven to be helpful in the development of hundreds of units but are not being offered as the only approach or necessarily as the 'right' sequence to go through when developing units. As teachers become familiar with the process they may create their own steps for thematic unit development.

I. SELECT A THEME
   A. Consider the Real-Life Situation Model described above.
   B. Consider the Possible Theme Categories-Topic, Issue, Problem, Concept or Process.
   C. Consider various Sources of Ideas for Themes. Almost anything could serve as an idea source when looking for a unit topic, issue or problem. Certainly science curriculum guides at the state, district, school and grade level may suggest or dictate themes. If a textbook has been adopted for your grade level, the units or chapter titles may also suggest themes.

   Beyond these somewhat forced sources, you will also want to look for ideas from such places as:
      1. The children-their questions, interests, needs, etc.
      2. The childrens' parents and acquaintances-their hobbies, interests and occupations.
      3. The principal's or other teacher's ideas for school-wide themes.
      4. Your own interests, travels and ideas.
      5. Things - resources in the classroom, neighborhood, community, state as well as things children bring to school.
      6. Nontextbook resources such as popular movies, television shows, children's literature and current events.
      7. Issues or problems involving science, technology and society (STS) that are of local concern appearing as news stories in the local newspaper.
      8. Supplemental resources such as Outdoor Biology Instructional Strategies (OBIS) modules, Elementary Science Study Booklets, Biological Science Curriculum Study (BSCS) and Science 5-13 Books which are themselves thematic units.
   D. Consider Criteria for Selecting an Appropriate Theme. The decisions concerning appropriate themes must be made on the basis of a teacher's knowledge of the students, the school, the community and numerous established educational goals. Thus, themes will be varied and will usually change from year to year. Following are a few suggestions to be considered when selecting appropriate themes for science units:
      1. Any idea or theme suggested by students has the built-in advantage of being relevant, current and meaningful to children.
      2. Remember, any idea or theme should be motivating to you as well as the children. You will find you do a better job preparing units for themes you believe are interesting and of prime importance to students.
      3. Based on the premise that students learn by doing and by thinking about what they have done, the unit should lend itself well to many hands-on activities.

4. A theme should not be too broad or too narrow. One that takes more than two months (one month for younger students) is probably too big. If, when brainstorming the theme (discussed later), very few ideas come to mind, the theme is probably too narrow.
5. The theme should be appropriate for the age and grade level of the students. Piaget's theory can be used to help make these decisions.
6. Finally, any theme selected must contribute to the overall goals and objectives of the state, district and school.

II. DEVELOP THE THEME

A. Define the Theme Preliminarily. Write a one or two sentence definition or description of what the theme means to you. This helps to guarantee you and other users of the unit will have a clear idea of what you were specifically referring to by your theme.
B. Create a Preliminary Rationale. Write a paragraph or two which explains why the theme is important for your particular students. What does it have to offer? This helps provide criteria for completing the next few steps.
C. Write Tentative Broad Goals. Identify what you think may be the broad knowledge, skill and attitude goals suggested by the rationale statement.

III. BRAINSTORM THE THEME

A. Brainstorm All Related Ideas. Write the theme on a piece of paper and begin writing down the ideas this theme suggests. Osborn (1976) has these suggestions for getting the most out of the process:

1. Defer judgement. Analysis and criticism come later.
2. Free-wheel. Hang loose. Think of the unusual, unique or bizzare. Don't worry about order or sequence.
3. Tag on. Don't wait for an idea. Make another one out of the last one given by changing it in some way.
4. Quantity is wanted. Don't hold back for a minute.
5. Be childlike in your thinking. How would students in your class respond to the theme? Better yet, allow the students to participate with you in the brainstorming. This will give you clues to the student's knowledge of the theme as well as determine their interest in the theme.

B. Consider a "World's System View" to Add to and Broaden the Brainstorming. According to McGowan (1987), any issue or problem must be considered from the following world systems: environmental, economic, political, cultural and scientific and technological. If your theme is dealing with an issue which is broad in scope, brainstorm the possible environmental, economic, political, etc. relationships.
C. Consider the Science, Technology and Society (STS) Relating Components. While somewhat similar to the above considerations, a revised version of the Far West Laboratory's Model of Scientific Literacy (Mitman, 1987), suggests that in

addition to considering the Content of Science and Technology, the following relating components should also be brainstormed: The Reasoning Process of Science and Technology, The Societal Impact of Science and Technology, The Social/Historical Development of Science and Technology and The Personal Use of Science and Technology as related to the theme under question.

Keep in mind, however, that not all of the above components will necessarily be appropriate for every theme or every grade level.

IV. CREATE AN IDEA WEB FOR BRAINSTORMED IDEAS

A. Analyze, Synthesize and Categorize Ideas. Look over the big list and on a separate piece of paper put those together that for some reason belong together.

B. Identify Major Subthemes and Subtopics or Subissues or Subproblems that Emerge.

C. Begin the Idea Web. Place the theme in the center of a new piece of paper and arrange the labels for the subthemes in appropriate places on the paper. Draw arrows showing potential relationships between subthemes.

D. Add to the Idea Web. Go back to the list of items for each Subtheme. Add the ones you think have merit and answer the following questions for additional ideas.

1. Where is the science, social studies, mathematics, language arts, reading, etc.?
2. What children's books, stories, songs, music and games relate to the theme?
3. How could the school site, community and state resources contribute to the unit?
4. What other available resources could be used with the specific subthemes?
5. Who could be used as resource people and experts for the unit?
6. Are there future or significant historical events which could serve as focal points?
7. What activities that I know about could be done by the students?

E. Redo the Idea Web so that it includes only the Ideas you think Most Appropriate.

V. DETERMINE SCOPE OF THE UNIT

A. Make a List of the Subthemes, Concepts, Process Skills and Attitudes to be Emphasized.

B. Make a Final Determination of How Much and Which Parts of the Idea Web to Use in the Unit.

C. Identify the STS Relating Components (See step III-C) used.

D. Think About How Long the Unit Should Last. The length should correspond to the needs of the students, your own interests, the availability of resource material, and the overall placement of this particular unit in the total year's science curriculum.

VI. RESEARCH AND RESOURCE THE UNIT

A. Gather Background Resources for You and the Students. Read up on the theme.

B. Gather Ideas for Instructional Activities from Exisitng Programs, Supplemental Materials, Children's Literature, Media, Possible Field Trips and Guest Speakers.

C. Collect Materials and Equipment for Students and You.

D. Make a Final Determination of How Long the Unit Should Last.

VII. DETERMINE UNIT SEQUENCE

A. Redefine the broad goals so that they are Consistent with the Subthemes, Concepts, Process Skills and Attitudes Identified Above.

B. Identify Prerequisites - Concepts, Skills and Experiences Needed to Begin and Participate in the Unit. These should be translated into instructional activities for inclusion as part of the Introductory Phase of the unit.

C. Identify Topics and Activities for the Introductory Phase of the Unit. There are two types of Introductory Activities:

1. Those which meet the needs for providing prerequisite knowledge, skill and experience.
2. Those which INTRODUCE, through concrete experiences, the main topic, issue or problem which is the focus of the unit.

D. Identify Appropriate Topics and Activities for the Extending Phase of the Unit. These activities should EXTEND students' understanding of the main theme of the unit. Generally, students have a chance to do this by finding and using other examples of the main theme.

E. Identify Appropriate Topics and Activities for the Concluding Phase of the Unit. There are two types of Concluding Activities:

1. Those designed to bring to a conclusion or closure activities and ideas begun during the Introductory or Extending Phase of the unit.
2. Those designed to allow students an opportunity to apply their newly acquired knowledge and/or skills to a new situation.

F. Create Unit Glue. "Glue" represents those types of activities or unit features that hold the unit together from start to finish (often necessary if there is not a textbook or workbook to serve this purpose). Such things as student record books or journals, bulletin boards, long-term projects and learning centers may provide the necessary "glue" to keep the unit together.

G. Create a Unit Structure Chart. This chart should serve as both a table of contents and allow a teacher to see at a glance how the various activities relate to one another and to the unit goals. Such a chart could include the following information: Name of Lesson, Goal Achieving, STS Component, Learning Mode, Time, and Source.

VIII. FINALIZE THE UNIT
    A. Finalize the Unit Theme Definition.
    B. Finalize the Theme Rationale
    C. Finalize the Broad Goals

IX. CREATE AN APPROPRIATE UNIT TITLE

X. WRITE LESSON PLANS FOR EACH ACTIVITY

XI. DETERMINE PROCEDURES FOR MEASURING AND EVALUATING STUDENT SUCCESS WITH THE UNIT GOALS AND OBJECTIVES

XII. IMPLEMENT AND EVALUATE THE UNIT

ANATOMY OF A THEMATIC UNIT. If you use the models suggested above you've gone through twelve steps for creating a thematic unit. Once complete the finished product will have the following components:

I. TITLE PAGE

    Unit Title
    STS Relating Components
    Authors, Schools
    Grade Level(s)
    Approximate Time

II. RATIONALE

III. GOALS

IV. IDEA WEB

V. STS RELATING CHART

VI. UNIT STRUCTURE CHART

VII. INSTRUCTIONAL ACTIVITIES
    Introductory

    Extending

    Concluding

    Glue

VIII. ASSESSMENT PROCEDURES

IX. APPENDICES

SAMPLE YEAR OF THEMATIC UNITS. The thematic unit approach described here places the teacher in the center of the decision making process. If used as a total curicular approach, care should be taken to insure a balanced utilization of topic, issue, problem, concept and process theme categories. A sample of the balance of units that could make up a Middle Grade curriculum is shown below:

3 Weeks - Process Theme, either OBSERVING (an essential ingredient for inquiry learning), COMMUNICATING (another essential ingredient that will deal directly with the Expression component of the Brain Compatible Model of Instruction (See Cohen, et. al. 1989) or MEASURING METRICALLY (which may be dictated in some schools, districts or states).

3 Weeks - Concept Theme, SYSTEMS (this would be selected by referring to texts, children's interests, your interests, and current events). This theme lends itself to all brances of science and much of the social sciences.

3 Weeks - Process Theme, PREDICTING, DATA COLLECTION, EXPERIMENTING AND GRAPHING (these are additional skills needed for the experimentation phase of inquiry learning and will provide prerequisite experiences for future thematic units.

5 Weeks - Issue Theme, PALO VERDE NUCLEAR POWER PLANT: PROS AND CONS or some other issue of real concern to your students or your locale. Here students will have a chance to utilize some of the previously learned skills and concepts to actually understand an issue of concern to many as well as begin to formulate a position on the issue.

5 Weeks - Topic Theme, THE SONORAN DESERT or other appropriate geographical area emphasis. If possible this should include a two day/night outing to an outdoor education center as a concluding or generalizing activity.

5 Weeks - Problem Theme, open and mutually planned by the teacher and students. Each student or small group of students will be responsible for learning about and then "informing" fellow students about some portion of the problem. As a class, students will identify possible approaches to solve the problem, weigh the consequences of each approach and then select the most appropriate approach and take action suggested by this approach to help resolve the problem.

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The Learning Power Index

Bill Stonebarger

How can you tell how useful a learning material will be in teaching science, technology, and society?

In "What Do You Care What Other People Think?," Richard Feynman, Nobel prize winning physicist who was on the panel investigating the Challenger tragedy, tells a story of questioning space shuttle engineers.

"They keep referring to the problem by some complicated name--a pressure-induced vorticity oscillatory wa-wa, or something. I said, 'Oh, you mean a whistle!' Yes, they said, 'it exhibits the characteristics of a whistle.'"

I'm afraid only too much of our talk about bringing science/technology/ society to the classroom sounds like these space engineers.

Consider, for instance, this description of one of the new STS programs from BSCS. "The module discusses technology assessment as a societal attempt to investigate rationally actual and potential impacts of technological innovation and introduces a model for decision making at the personal and public levels."

To the teacher considering using this module what can you say? "Good luck. Whistle when you get stuck."

I prefer the approach of Henry David Thoreau who wrote "our life is frittered away by detail ... simplify, simplify."

How? How can we simplify?

Let's start by bypassing all the impossibly high-fog objectives, principles, rationales and standards that are so common in educational jargon and so commonly ignored in practice. Let's put to one side for the moment the high-sounding but often empty rhetoric beloved by national commissions of alarm. As Walter Gratzer, a medical researcher in Britain, recently wrote in the British science journal, Nature, "it is mostly a lot of pompous bunkum ... We all know that no proposition is so foolish or meretricious that at least two Nobel laureates cannot be found to endorse it."

If not here, where can we start then?

For me one of the simplest and best ways to look at education was given by the philosopher Alfred North Whitehead. He pointed out that all significant learning proceeds in a three stage cycle: Romance, Precision, Synthesis. You get interested, you study, and you make some sort of meaningful combination of what you are learning now with what you knew before.

In other words, you build a network of mental road maps. When you are very young the road maps are very simple. As you get older and more educated the mental road maps become richer and more sophisticated.

This gives us some clues. Especially when it comes to general education. To teaching basics of science, technology and society. To teaching basic scientific literacy. (Or even for what critics like Morris Shamos prefer to call science appreciation.)

Simply speaking, a useful learning material would be one that interests you, one that you can understand, one that teaches you new things, and one that helps you connect these new things in ever more powerful networks of the mind.

Interest is difficult (I'll come back to that later), but let's see if we can quantify each of the other three factors-- ease of understanding, teaching new things, and connecting new things in networks. (Staying as far away as we can from "pressure induced vorticity oscillatory wa-was.")

New cars have stickers that tell you how much horsepower they have, many miles per gallon you will get, and many other useful numbers. Wouldn't it be nice if we had stickers that would tell us in numbers how much learning power there is in any given textbook, video tape, computer disc, lab manual, magazine article, trade book, or whatever.

As you have no doubt guessed I have such a sticker in mind. I call it the "Learning Power Index." Judiciously used, I think the Learning Power Index can make the teacher's work easier, more effective and more interesting.

Remember the three qualities a good learning program should have--(1) be easy to understand; (2) teach new things; (3) relate these new things to each other and to things already in the mind in networks of progressive sophistication.

Let's start with ease of understanding. One simple test of how difficult a learning material is to understand is the Fog Index. This easy-to-calculate number was first invented by the Gunning-Mueller Clear Writing Institute. The Fog Index will give you a rough measure of how many years of schooling are needed to understand a given passage.

To find the Fog Index the rules are simple. Using a representative sample of your selection: (1) Find the average number of words in each sentence. (2) Calculate the percentage of words that are three syllables or more. (3) Add these two figures, and then (4) multiply this sum by 0.4. The resulting figure is the Fog Index, a rough measure of how many years of schooling would be needed to understand the passage.

The Bible, Shakespeare, Mark Twain and TV Guide all have Fog Indexes of about 6. Time, Newsweek, the NY TImes and Wall St. Journal have Fog Indexes of about 11. This paper has a Fog Index of about 10. The passage I quoted of BSCS module has a Fog index of 26! How many teachers have 26 years of schooling under their hats? You might like to calculate the Fog Index of the next curriculum guide you get from your superintendent or dean of studies.

Making a learning material easy to understand is a third of the battle. There also has to be something worth understanding. And it has to make, or at least contribute to making worthwhile connections, networks in the mind.

For science/technology/society, as well as for scientific literacy itself, what is "worth understanding?" How can we choose which bytes and pieces of knowledge are likely to be the most useful to our students.

I suggest to you that E. D. Hirsch Jr. in his recent best seller, "Cultural Literacy," has given us some clues here and pointed us in a more productive direction than most high-fog commissions.

Hirsch, along with his colleague, the physicist James Trefil, simplifies things. He argues that the educated person is the person who knows the meaning of about 5000 terms, concepts, ideas, names and sayings. All of them are listed in a straightforward simple list in his book. Roughly 800 of these terms, concepts, ideas, names and sayings are related to science and technology. Hirsch and Trefil suggest, and I agree with them, that being scientifically literate is not all that mysterious. It merely means the person has a working network of the mind that includes these 700 to 800 terms, concepts, ideas, names and sayings. Being literate in science, technology and society means having a working network of the mind that connects the scientific terms to the other terms in the list that Hirsch labels "what every American needs to know."

Unlike so many of the well-meaning but almost universally ignored in practice educational theories, the Hirsch theory is not over-ambitious. These items on the list are broad in scope, but shallow in depth--no "in-depth" learning required, thank heavens!

Here are some samples. From geography: Pacific Ocean, the Alps, Moscow, Paris, South Africa, Utah, Antarctica. From history: World War I, World War II, Julius Caesar, Abraham Lincoln, Lenin, Roosevelt, 1776, the New Deal. From literature; Alice in Wonderland, Hamlet, Sophocles, Walt Whitman, Henry David Thoreau, Mark Twain. From science; gene, atom, photosynthesis, evolution, radiation, Darwin, Mendel, Watson and Crick, ecosystem, recombinant DNA.

As Hirsch points out, the educated person today does not necessarily know a great deal about any one of these concepts. He or she is not a specialist in Elizabethan literature, Civil War battles, nuclear physics or genetic engineering. But he or she does know enough about almost all the terms on the list to recognize them when heard or read, and to place them in some kind of meaningful context. He or she can read Time Magazine, the New York Times or the Wall St Journal and understand the articles. In short, knowing this list is a pretty large part of what we mean when we consider a person educated or not. Literate or not.

Let's use this list to help measure the "learning power" of educational materials. Again, let's keep it as simple as possible. How many concepts from the list does the given learning material teach? (Naturally educators are free to add to or subtract from Hirsch's list--or to make up their own list to fit particular needs and situations. I personally think the Hirsch list is a good starting point for general liberal education. For specialized vocational and professional education you would obviously need a more specialized list.)

Now we have two numbers. The Fog Index tells us how easy the learning material is to understand. The "list count" tells us how many important concepts are taught. Now we need just one more number to calculate the Learning Power Index.

As Hirsch himself takes pains to point out, we don't want to simplistically "teach the list." Our minds are not computers. They can't be effectively programmed with miscellaneous information. Any new information must be meaningfully connected. It must become a working part of those ever richer networks of the mind.

How can we measure the network connections?

Here is one way I have come up with. We could count how many intellectual dimensions the given learning material enters--how many "general education" connections are made.

I suggest we use the following sixteen dimensions: Life Sciences, Earth Sciences, Physical Sciences, Health (including Psychology), Technology, Economics (including careers), Political Science (including law), History, Geography, Literature, Philosophy and Religion, Arts, Mathematics, Communications (esp. English), Methods & Values, and finally, Popular Culture. The more of these dimensions that a given learning material connects the better. The more of these dimensions that are linked together in ever richer networks of the mind, the better--the more educated the student becomes.

Go through the learning material selection and simply count how many of these dimensions are entered. Now we have our third number.

We put all three of these numbers together. To find the Learning Power Index of any given learning material you multiply the number of concepts taught by the number of dimensions entered, and you divide this product by the Fog Index.

Other things being equal, then, the more concepts taught the better. The more dimensions entered the better. And the lower the Fog Index the better.

Let's take an example to see how this works in practice. Let's compute the Learning Power of a segment from the popular "Modern Biology" (Holt, Rinehart and Winston) textbook, typically used at the 10th grade level in high schools.

The Holt textbook devotes 66 pages to teaching about one of the most important of modern life science concepts, the gene. To do this it uses approximately 10,000 words in the text, diagram captions, picture captions, questions, and exercises. I calculate the Fog Index as 14. That will be the denominator of our fraction.

I count 52 concepts (from the Hirsch list) taught in those 66 pages. The vast majority of these concepts are from one dimension--Life Science. Concepts like gene, Mendel, hybrid, heredity, dominant, recessive, egg, sperm, DNA, etc. For the sake of this illustration I do not count concepts taught that are not on the Hirsch list, though you may decide you want to enlarge the list for your purposes. The question you have to decide--is it really important for general education and indeed for basic scientific literacy or science/technology/society that the student know concepts like Punnett Square, phenotype, endoplasmic reticulum, purines, triplet codons, initiator codes, etc. If you say, yes it is, ok. But are you also prepared to leave out other concepts and/or connections to accommodate these more technical and specialized terms? As the comic Steven Wright puts it, "You can't have everything. Where would you put it?"

In the Holt selection I count seven dimensions: (1) Life Science; (2) Physical Science (chemistry); (3) Mathematics; (4) Health; (5) History (a bare minimum without much drama or interesting detail); (6) Methods and Values (again, a surprising lack of detail or insight); and finally (7) Economics (a very little, but I'll give them the benefit of the doubt).

Since the Learning Power Index is a power measure, we have to take time into account. People read at different speeds, however, so let's standardize on the actual number of words used in the learning material rather than the time spent reading them.

I suggest using 1500 words--the length of an average feature article in a good magazine--as a standard. In our example then, we have to correct from the 10,000 words the textbook used to teach 52 concepts in 7 dimensions to what it teaches in 1500 words. A simple proportion of 364 is to 10,000 as x is to 1500 yields a figure of 55 (rounded off) as the numerator of our Learning Power fraction.

Now, putting it all together. Learning Power Index is the number of concepts times the number of dimensions (corrected to 1500 words) divided by the Fog Index. In the case of Holt's Life Science textbook selection, this means 55 divided by 14, or a Learning Power Index of 4.

I tested 10 different textbooks in junior and senior high school science and found a range of Learning Power Indexes between 2 and 7. Typically these textbooks had few dimensions and while they did teach a large number of concepts, most of these concepts were highly specialized ones, not on the Hirsch list. Again--if you insist on the necessity of teaching these more technical and specialized terms, concepts and ideas are you also prepared to leave out what I would consider far more important general education terms, concepts and ideas?

Is it more important for instance to learn details of animal and plant classification systems or to learn details of how Darwin came upon the theory of natural selection. The geography of his round-the-world trip on HMS Beagle? The controversies that evolution theory has sparked in his day and in ours?

Is it more important for general education to learn how to cope with terms like cephalathorax, uracil, Klinefelter's syndrome, and monohybrid crosses, or to learn how Watson and Crick cracked the DNA code? Where Cambridge University is? How genetic engineering works--in rough outline, not technical detail?

Is it more important for general education to learn details of quantum states of the atom or to learn what part people like Niels Bohr, Ernest Rutherford, and Enrico Fermi played in discovering details of the atom? What part the Second World War played? How the atom is intimately related to just about all sciences and technologies today, including psychology and political science?

In teaching some of these latter details a great many of the terms on the Hirsch list come up, and a great many of the dimensions on my list are entered. In teaching the former few terms on the Hirsch list come up, few dimensions are entered, few connections are made. I even suspect that for the vast majority of students those specialized terms and connections that are made are much more easily forgotten since they do not connect to useful mental networks.

Where can the teacher find materials with higher Learning Power Indexes? Materials that do teach the most important concepts and connect with the richest dimensions?

I have only sampled and encourage others to use the Learning Power Index idea to make more systematic studies. I would also like to see studies of how the Learning Power Index would correlate with tests of scientific and cultural literacy. Yes, even to performance on college entrance tests.

In my limited sampling I found that supplementary science enrichment books and television specials did a good deal better on the Learning Power Index than textbooks. Here are a few sample Learning Power Indexes that I calculated: four NOVA segments averaged 11; Bronowski's series "Ascent of Man" scored 15; Carl Sagan's "Cosmos," 12; sample of Science Study Series books, 10; sample of Isaac Asimov books, 11; five National Geographic sound-filmstrips, 15; three science articles in NY Times Science section, 18. On the order of three times the learning power of the typical textbook in other words.

For teachers facing a semester or year's course in science, or in STS, one problem with these supplementary enrichment learning tools is just that--they are designed to be and are supplementary. It would be difficult for the teacher to put together a whole course in biology, physics, or even general science using only such supplementary materials. You would end up with large gaps. It would be relatively easy to cover such popular topics as wildlife and nature, environmental crises, energy problems, etc. It would be difficult to find much material on the more basic concepts that are needed to understand these popular topics.

Perhaps this is one of the reasons the vast majority of teachers rely on the basic textbook even down into elementary grades. Is it wise though to use any learning material for general education, and certainly for STS education that has a Learning Power Index less than 10? Often less than 5. Remember, this low figure means that the material either does not teach many important concepts or it does not relate them to very many dimensions. Or more likely, both. (It could mean that it has a very high fog index, though this is not likely with most materials presently produced for elementary and high school use. It does apply often to the advertisements for these materials however, their rationales, aims, etc. And definitely does apply to most of the curriculum guides written and published by low and high-level committees. Very high-fog indeed!)

It seems to me that textbooks as presently written and published are for the most part counter-productive when it comes to general scientific literacy and science, technology, society connections. They teach too many non-essential concepts and relate them to far too few dimensions. I think these two grave faults also play a big part in leading to the proverbial problem of boredom with science classes. To the poverty of Romance in science education.

True, for some the Romance of science comes with hands-on lab and field activities. However, my own 18 years experience teaching BSCS, CHEM study, and PSSC labs, leads me to believe that hands-on science is not all its cracked up to be either. In my experience, only a small proportion of students are genuinely turned on and truly educated by the lab activities. Alas, for most, rather than teaching them "problem solving skills" or "critical thinking" or (from the new California Model Curriculum Standards for Science) "learning techniques that comprise the scientific method to validate knowledge and to develop thinking skills for lifelong learning" -- only too often students learn that labs are places that smell bad, places where you cut up frogs, fudge figures and indeed, places where magic shows sometimes happen. I am not suggesting we should abandon lab science, but I am suggesting we give "hands-on" science the same cold analysis we give textbooks and other learning strategies.

Some insight into this matter of Romance Power can be gained by studying the 75th anniversary issue of American Scientist (Sept./Oct. 1988). Among other goodies, they have collected 75 reasons to become a scientist from 75 living American scientists. The reasons cover a lot of territory.

Jane Goodall and Edwin Land gave the most succinct reason--"curiosity." Abraham Pais, professor of physics at The Rockefeller University chose science "because it seemed the most fun." Rudolph Arnheim, professor of psychology at

Harvard used a biblical text, "The wise man's eyes are in his head; but the fool walketh in darkness." Matt Cartmill, professor of biology at Duke University, wrote: "As an adolescent I aspired to lasting fame, I craved factual certainty, and I thirsted for a meaningful vision of human life--so I became a scientist. This is like becoming an archbishop so you can meet girls."

If you read all 75 reports and sort out all the reasons given, you find some surprises. By my count the most common reasons for becoming a scientist were philosophic and aesthetic ones--curiosity, beauty, simplicity, romance, meaning of life, etc. In second place came the influence of media--museum exhibits, moves and books. Especially books. Among the books and authors cited were Jules Verne, Paul de Kruif's "Microbe Hunters," Bernard Jaffe's "Crucibles of Chemistry," C. P. Snow, George Gamow, and biographies of people like Marie Curie, George Washington Carver and Leonardo da Vinci.

In third place was the influence of parents--often scientists themselves. Fourth came outstanding teachers--elementary, high school and college. And finally tied for fifth place was "hands-on" activities at home and in the field. Tinkering, hobbies, collecting insects, bird watching, etc.

Notice the conspicuous absence of the two most widely used methods of school science--textbooks and "hands-on" lab exercises. Exactly zero of the scientists made any mention of either one.

So what are some alternatives? How can the teacher find materials that have both Romance Power and a high Learning Power Index?

I hope you will pardon me for ending this paper with something of a commercial for our own learning materials. We at Hawkhill have created a new kind of minitextbook that does teach a great range of general STS concepts in a rich variety of dimensions and with low fog indexes. A series that can be used by teachers in various combinations as a foundation for their own basic science literacy or STS courses.

In fact we have gone one step further. We are attempting to yoke together the two most powerful communication media of the 20th century, the power of print and the romance of video. We call our new series TIME, SPACE & SPIRIT--Keys to Scientific Literacy. I'm a bit embarrassed to tell you what our Learning Power "stickers" say, since you will think I concocted the whole idea just to sell our own materials. Candor requires I report to you, however, that the members of our new series have the highest Learning Power Indexes of any of the materials I have so far tested. The Gene, (both textbook and video), for instance, has a Learning Power Index of 24 (this is six times that of the Holt textbook which teaches the same basic concepts). Other members of the 16-part series range between 18 and 35! From 4 to 10 times the Learning Power of standard textbooks!

If you were to use all 16 of our Keys to Scientific Literacy programs you would teach approximately 75% of the science and technology terms on the Hirsch list, and you would relate them to all sixteen of the dimensions I listed. This means as a bonus your students would also learn a great many of the "cultural literacy" terms, especially in the all important areas of history and geography.

We are working on new programs (primarily in the health and human physiology areas) that will bring this percentage to near 100% in the near future.

We think the combination of live action video and readable minitextbook, each packed with important concepts and rich dimensions will go a long way toward perking up the Romance part of our Romance, Precision, Synthesis format as well.

It's a start. We encourage and challenge competition to enter the field and create ever richer varieties of learning materials, all with high Learning Power Indexes--and high Romance.

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A DECADE OF S/T/S IN U.S. SCHOOLS

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A decade has passed since Norris Harms introduced Science/Technology/Society (S/T/S) into U.S. science education. He included S/T/S as one of the five focus groups for Project Synthesis, a research effort utilizing a variety of data bases for determining Desired State and Current State conditions for K-12 science. The discrepancy model was used to identify differences between the two states and to recommend procedures for moving the current state closer to the desired state. S/T/S was selected as one of the major foci for school science, along with elementary school science, science as inquiry, biology, and physical science. Many who followed the Project Synthesis effort questioned the inclusion of S/T/S and confessed to ignorance as to its features.

To be sure S/T/S was known outside the U.S. National curriculum efforts were newsworthy in international circles as S/T/S programs emerged in the United Kingdom, the Netherlands, Israel, and other developed nations. And, S/T/S had become a common development at the college level as NSF stimulated innovative programs; support was provided for a variety of course/program developments and institutes for colleges.

The National Science Teachers Association (NSTA) also became an active force for promoting S/T/S in the U.S. The NSTA Position Statement for New Directions for the 80s asserted: "The goal of science education during the 1980s is to develop scientifically literate individuals who understand how science, technology, and society influence one another and who are able to make use of this knowledge in their everyday decision-making. This individual both appreciates the value of science and technology in society and understands their limitations." Two NSTA yearbooks focused on analyses of S/T/S initiatives as a recommended rationale for improvements in school programs. And, in 1982 NSTA endorsed the Desired State descriptions from Project Synthesis as criteria of excellence for its Search for Excellence programs across the U.S. This meant that the S/T/S criteria were circulated widely and held as a model as innovative and effective school programs were sought for recognition and study. By 1985 S/T/S was recognized as a critical component in the school science curriculum and a second national search for exemplars was undertaken by NSTA.

Basic to the NSTA effort has been recognition of the four justifications/goals for school science programs for all students through the thirteen year continuum common in American schools. Harms employed the thinking of a panel of experts for identifying the basic goals as one organizer for his Project Synthesis study. These goals were:

1. **Science for Meeting Personal Needs.** Science Education should prepare individuals to use science for improving their own lives and for coping with an increasingly technological world.
2. **Science for Resolving Current Societal Issues.** Science education should produce informed citizens prepared to deal responsibly with science-related societal issues.
3. **Science for Assisting with Career Choices.** Science education should give all students an awareness of the nature and scope of a wide variety of science and technology-related careers open to students of varying aptitudes and interests.
4. **Science for Preparing for Further Study.** Science education should allow students who are likely to pursue science academically as well as

professionally to acquire the academic knowledge appropriate for their needs.

The final report of Project Synthesis ten years ago indicated that there was virtually no attention to any goal area other than the belief that the concepts included in a given course at a given academic level were important because they prepared students for the next course and/or the next grade level. There was little evidence that any of the other three goal areas were affecting the curriculum, the instruction used by teachers, evaluation techniques and instruments, or teacher education programs.

The Project Synthesis report ended with seven recommendations (in priority order) for improving science programs in schools. The needs were identified as:

1. A major redefinition and reformulation of goals for science education; a new rationale, a new focus, a new statement of purpose are needed. These new goals must take into account the fact that students today will soon be operating as adults in a society which is even more technologically-oriented than at present; they will be participating as citizens in important science-related social decision. Almost total concern for the academic preparation goal, as is currently the case, is a limiting view of school science.
2. A new conceptualization of the science curriculum to meet new goals; redesigns of courses, course sequences/articulation, and discipline alliances are needed. The new curricula should include components of science not currently defined and/or used in school. Direct student experiences, technology, personal and societal concerns should be foci.
3. New programs and procedures for the preparation, certification, assignment, and the continuing education of teachers; planned changes, continuing growth, and systems for peer support are needed. With new goals and a

new conceptualization of the science curriculum, teachers must have assistance if their meaning is to be internalized. Without attention to inservice education, new directions and new views of the curriculum cannot succeed.

4. New materials to exemplify new philosophy, new curriculum structure, new teacher strategies; exemplars of the new directions, i.e., specific materials for use with learners, and constantly needed. They provide concrete examples for use in moving in such new directions.

5. A means for translating new research findings into programs for affecting practice; a profession must have a philosophic basis, a research base, a means for changes to occur based on a new information. Separation of researcher from practitioner is a major problem in science education: all facets of the profession must work in concert for major progress to occur.

6. Renewed attention to the significance of evaluation in science education; self-assessment strategies, questioning attitudes, massing evidence for reaching decisions on instruction, and student outcomes are basic needs. Without such questions, observations, and judgments, future changes will be merely haphazard occurrences.

7. Much greater attention to development of systems for implementation and support for exemplary teaching and programs at the local level; current erosion of support systems for stimulating change and improvement in science education at all levels is a major problem.

Currently S/T/S programs are seen by many as attempts to respond to these seven recommendations. S/T/S programs represent a new rationale for science; they are new conceptualizations for the curriculum; they require new behaviors for teachers; they introduce new strategies and instruments for measuring success; they encourage teachers as researchers; they focus upon teachers as learners and facilitators of student efforts. Even though this is the case, the seven priorities for action remain ten years later as continuing priorities--even as S/T/S efforts intensify and are underway in schools in every state.

The revival of NSF support for science education activities has resulted in major funding for S/T/S efforts across the U.S. Of course, one of the largest has been the S-S/T/S project and the newly funded S/T/S Network Project at Penn State University. The Network Project is establishing regional centers involving science and social studies consultants from state Departments of Education and ten supervisors/leaders in each state prepared to assist schools and teacher groups with establishing S/T/S programs. A professional society--the National Association for Science/Technology/Society (NASTS)--has been formed under the leadership of Rustum Roy at Penn State. Roy's vision that S/T/S is a megatrend in science education is becoming a reality.

Several S/T/S initiatives in Iowa exemplify how S/T/S programs have been conceived for K-12 schools, how they operate, and the results achieved with students. An Honors Workshop program was funded by NSF in 1983 at the University of Iowa--among the first six programs funded as new priorities in science education were established. The Honors Workshop enrolled 390 teachers and supervisors over a five year period and focused upon STS efforts. Iowa also became one of 17 centers for another NSF project administered by NSTA--the Chautuaqua Program. Operating in Iowa for a three year period, 200 teachers from grades 4 through 9 were enrolled during the academic year as they developed and evaluated STS modules. The Iowa Utility Association endorsed the program and has continued major support for it for six years. Another 300 Iowa teachers have been involved.

The S/T/S efforts in Iowa have arisen directly from the S/T/S efforts envisioned by Joe Piel (SUNY Stony Brook, New York), who chaired the S/T/S Task Force for the Project Synthesis effort. Piel was the primary instructor for the Iowa Chautauqua Program for four years. The S/T/S efforts in Iowa provide a contrast in terms of the classroom prior to and following STS initiatives. These differences reported by teachers include:

	Before		After
1.	Students rarely look forward to science class; it usually means "getting out the science book"	1.	Eager enthusiasm; students begin work on their own
2.	Children falling asleep with traditional worksheets and books	2.	More motivation and student-initiated activity
3.	More "formal" approach	3.	Use imagination and special materials and equipment
4.	Many hated science; were not involved with any activities	4.	Favorite subject now for many students; students actively involved
5.	Low achievers did poorly	5.	Low achievers are involved; they raise their grades
6.	Poor attitude in many students	6.	At risk students can be equally, if not more, successful than gifted students
7.	Behavior problems	7.	Behavior problems subside
8.	Teachers feel uncomfortable when saying, "I don't know"; teacher seen as "expert"	8.	Teachers feel comfortable telling students, "I don't know, but let's do some research"; students as "researchers"
9.	Little active involvement by students	9.	Much investigation and many challenges; students very involved in class
10.	Students go through motions--take notes	10.	Students bring in newspaper articles, current topics, news items; students initiate study and investigation

11.	Students feel science is a worthless use of time	11.	Students develop a sense of pride in their class and accomplishments
12.	Science is isolated subject	12.	Science integrated among all curriculum areas
13.	Teachers have set routines and stay in their "own" classrooms	13.	Other teachers are involved with colleagues; team teaching and cooperation is greater
14.	Use only one science book and certain core units	14.	Other resources utilized to high degree, e.g., tapes, kits, newspapers, guest speakers
15.	Emphasis on definition/vocabulary and memorization	15.	Terminology incorporated intuitively as needed; emphasis on useful learning
16.	Grades easy to assign (daily grades and tests)	16.	Determination of grades is more difficult

Programs developed in such a manner result in a curriculum structure quite different from that found in the Project Synthesis studies ten years ago. Teacher behaviors also vary. S/T/S teachers in Iowa have provided videotapes of their teaching prior to S/T/S and one of a typical S/T/S classroom. They have reviewed each others' records and developed a list of contrasting descriptions. The following list indicates these major contrasts:

	Standard		S/T/S
1	Survey of major concepts found in standard textbooks	1	Identification of problems with local interest/impact
2	Use of laboratories and activities suggested in textbook and accompanying lab manual	2	Use of local resources (human and material) to locate information that can be used in problem resolution
3	Passive involvement of students assimilating information provided by teacher and textbook	3	Active involvement of students in seeking information that can be used
4	Science being contained in the science classroom for a series of periods over the school year	4	Science teaching going beyond a given series of class sessions, a given meeting room, or a given educational structure

5	A focus on information proclaimed important for students to master	5	A focus upon personal impact--perhaps starting with student curiosity and concern--not merely hoping to get to that level
6	A view that science is the information included and explained in textbooks and teacher lectures	6	A view that science content is not something that merely exists for student mastery simply because it is recorded in print
7	Practice of basic process skills--but little attention to them in terms of evaluation	7	A de-emphasis upon process skills--just because they represent glamorized skills of practicing scientists
8	No attention to career awareness, other than an occasional reference to a scientist and his/her discoveries (most were dead)	8	A focus upon career awareness--especially careers that students might expect to pursue as they relate to science and technology and not merely those related to scientific research, medicine, and engineering
9	Students concentrating on problems provided by teachers and text	9	Students performing in citizenship roles as they attempt to resolve issues they have identified
10	Science occurring only in the science classroom as a part of the school's science department	10	Science study being visible in a given institution and in a specific community
11	Science being a study of information where teachers discern the degree students acquire it	11	Science being an experience students are encouraged to have
12	Science focusing upon current explanations and understandings; little or no concern for the use of information beyond classroom and performance on tests	12	Science with a focus upon the future and what it may be like

Students are also found to be different as a result of major experiences with S/T/S. Assessment has centered in five domains that are important in science teaching. Figure I is an attempt to depict the domains and to define S/T/S in connection with them.

In regular science teaching nearly all attention is directed to the acquisition of information. (It probably cannot be called knowledge very often since so few students can ever demonstrate that they can use the information that is seemingly learned. It is common for school curricula and for teachers to embrace the importance of considering science processes. Nonetheless, there is little evidence that traditional science teaching is effective in helping students develop such skills--at least in a manner that encourages their use in other situations in addition to the ones used to illustrate them in the classroom.

Positive student attitude and certain aspects of creativity are seen as necessary attributes for S/T/S students--perhaps all students able to attain knowledge (useful information) and science skills/processes (useful in non-class settings). Positive attitudes and personal creativity are traits more easily attainable by dealing with issues in today's society and technology which affect the lives of all. In traditional science courses technology is often seen as irrelevant. (It was purposefully omitted from the pure science programs developed during the 60s!) And, current societal issues and topics that are readily related to responding to student needs and concerns are dismissed as health, psychology, or some other social study.

S/T/S programs are defined as those starting with real world issues and concerns. Hopefully these are (or can become) student issues and not some other kind of information teachers wish to present to students!

When teachers begin with a topic from the existing course outline, a favorite topic or science concept, or information that they have been wanting to share with students--problems are often encountered. When STS is viewed as the same science concepts as those appearing in the textbooks, but with technological and societal dimensions "added on" in that order, the experience proves less successful.

Many teachers begin with frustration. What will their STS modules be? How should the task be approached? The most effective STS efforts have arisen from sharing the frustration with the students, including the choice of problem, the need for a student-based effort, the need to use applications immediately in daily living. The best STS efforts are those where the student chooses the problem to be investigated. The problem comes from unusual circumstances. Some of the best have been students who report problems with toilets plugging at home, a faucet which does not turn off at school, a power failure in a school with no windows, a problem with a polluted water well, and hundreds of other problems identified by students.

One of the greatest problems with school science seems to be the belief that there is essential information found in curriculum guides and textbooks which teachers must force students to go over. When real problems are internalized and the students are encouraged to work on their resolution, the power of information is soon realized. Students search out information and use it; and in the process new problems are defined.

STS means dynamic teaching and learning. Effective science classrooms can not be passive ones where students merely go over information--information that will be used for examinations and/or activities that will verify its accuracy. In traditional science classrooms students are expected to remember, to get "the answer" on quizzes, and to make "correct" observations in the laboratory. Rarely is a real-life context provided.

STS means focusing on problems, on questions, on unknowns. It means searching for answers and explanations. However, this searching means that students encounter numerous new questions and problems. Sciencing is a never-ending process.

The best STS modules (and teacher experiences with STS) always result in teacher comments such as: "My STS module is not complete yet..."; "I just had to stop..."; "I never imagined that we would investigate so many questions..."; "I had no idea that STS would result in so much student initiative, enthusiasm, action..."; "The students did the work. They identified problems, proposed actions--they wouldn't let it stop!"

The place to begin new STS modules needs to reside with the students. They must see and buy into a problem. Real science learning cannot result from teachers "presenting" information or "announcing" the STS module. Students must have a hand in constructing the problem and determining their actions concerning it.

Students who experience science as S/T/S are different from students who complete a traditional science program organized around the typical concepts found in most textbooks. A look at differences in each domain illustrated in Figure 1 may be helpful.

	Traditional		S/T/S
		Concepts	
1.	Concepts are really pieces of information mastered for a teacher test	1.	Students see science concepts as personally useful
2.	Science concepts are seen as an outcome itself	2.	Science concepts are seen as a needed commodity for dealing with problems
3.	"Learning" is principally for testing	3.	Learning occurs because of activity; it is an important happening but not a focus in and of itself

4.	Retention is very short lived	4.	Students who learn by experience retain it and can often relate it to new situations

Process

1.	Students see science processes as skills scientists possess	1.	Students see science processes as skills they can use
2.	Students see processes as something to practice as a course requirement	2.	Students see processes as skills they need to refine and develop more fully for themselves
3.	Teacher concerns for process are not understood by students, especially since they rarely affect the course grades	3.	Students readily see the relationship of science processes to their own actions
4.	Students see science processes as abstract, glorified, unattainable skills that are inapproachable for them	4.	Students see processes as vital parts of what they do in science classes

Attitude

1.	Student interest declines at a particular grade level and across grade levels	1.	Student interest increases in specific courses and from grade to grade
2.	Science seems to decrease curiosity	2.	Students become more curious about the material world
3.	Students see teacher as a purveyor of information	3.	Students see teacher as a facilitator/guide
4.	Students see science as information to learn	4.	Students see science as helping to deal with problems

Creativity

1.	Students decline in their ability to question; the questions they do raise are often ignored because they do not fit into the course outline	1.	Students ask more questions; such questions are used to develop S/T/S activities and materials

2. Students rarely ask unique questions	2. Students frequently ask unique questions that excite their own interests, that of other students, and that of the teacher
3. Students are ineffective in identifying possible causes and possible effects in specific situations	3. Students are skilled in suggesting possible causes and effects of certain observations and actions
4. Students have few original ideas	4. Students seem to effervesce with ideas

Connections & Applications

1. Students see no value and/or use of their science study to their living	1. Student can relate their science study to their daily living
2. Students see no value in their science study for resolving current societal problems	2. Students become involved in resolving social issues; they see the relativity of science study to fulfilling citizenship responsibilities
3. Students can recite information/ concepts studied	3. Students seek out information and use it
4. Students cannot relate the science they study to any current technology	4. Students are engrossed in current technological developments and use them to see the importance and relevance of science concepts

S/T/S efforts have moved forward with dramatic pace during the ten years since Project Synthesis. S/T/S is becoming the megatrend that Rustum Roy proclaimed it to be. S/T/S activities are exciting and innovative developments in every state. S/T/S programs are affecting the entire school curriculum--not just the nature of science courses and teaching. Exemplary S/T/S programs represent major efforts and successes with realizing the priority needs identified ten years ago by the Project Synthesis research team. Perhaps it is time for a second Synthesis study to note with certainty the extent that S/T/S programs have resolved the science education issues so clearly identified in 1978.

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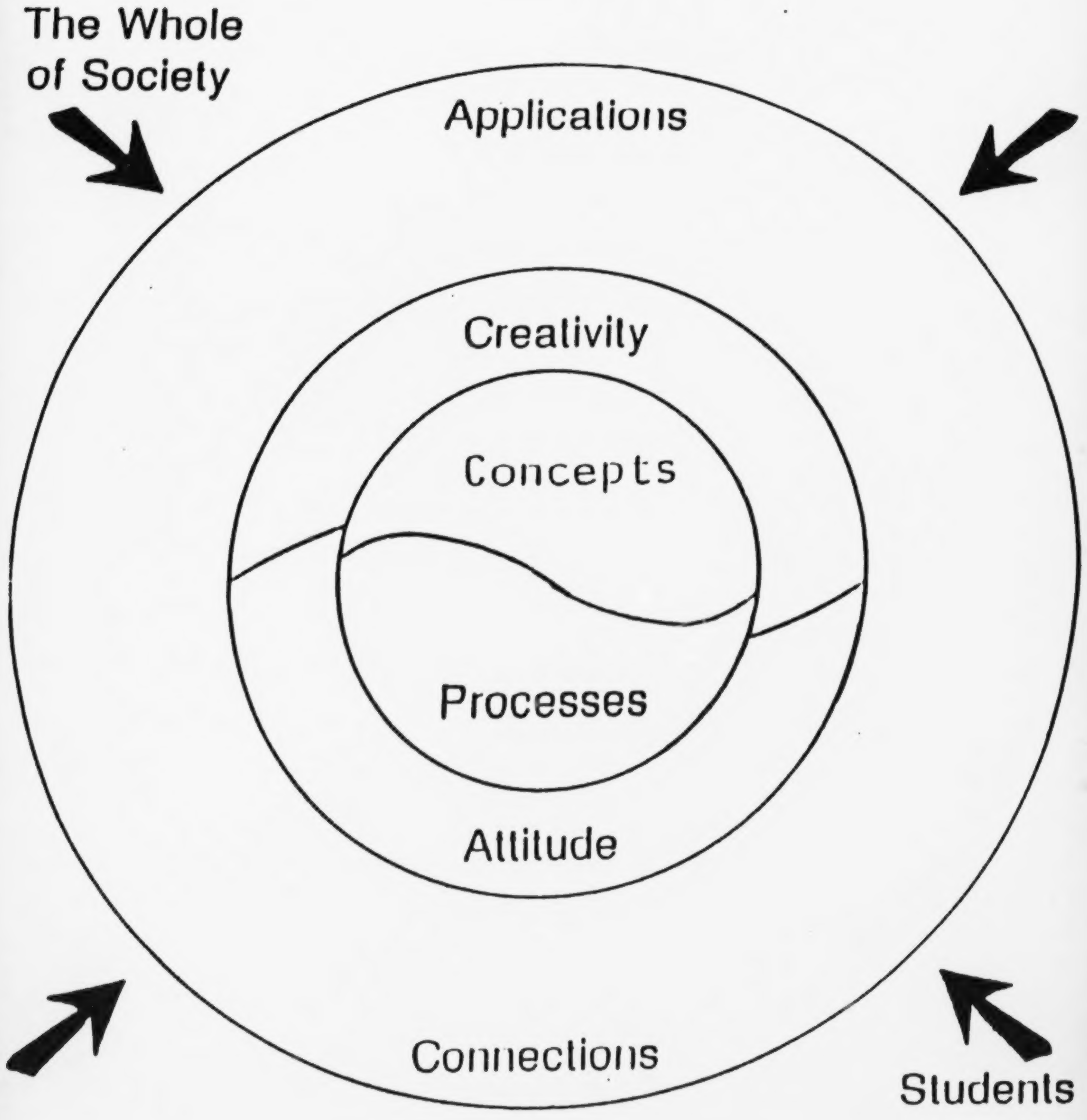
FIGURE 1
Model of Science/Technology/Society Programs


The Whole of Society
Applications
Creativity
Concepts
Processes
Attitude
Connections
Students

POETRY AS FOCUS FOR TECHNOLOGY, WORK AND VALUES

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PROLOGUE

Poetry is dead? So they say...

> Aye aye poetry is done for, vanished, kicked the bucket and gone up the flue and lost in the mountain snows of the latest plane crash, hunting parties on the way to gather the remains and study the debris....(Sandburg, 1960)

The hunting party on the way to rediscover poetry in this era of high tech is general education. Carl Sandburg's "joke" about the death of poetry points to the constant danger that art will be suffocated by science; that humane values will be suffocated by technology. Art and science, values and technology are, however, intertwined and inseparable.

Futurists tell us that our destiny includes the scientist, the farmer, the soldier and the administrator. The scientist will, of course, continue to be the tool maker so that we can be ever more efficient in controlling and manipulating our environment. Some form of farmer will meet the nutrition needs of the planet (perhaps several planets). Some form of military will keep order, and the administrator will be with us because "someone has to be responsible."

Futurists and educators often forget the most important member of the team, the poet/artist, who gives it all meaning and makes it all worthwhile. Indeed, it is the poet/artist who will point to the problems of the future--and to the solutions.

Students in the humanities, business administration or engineering have little opportunity to examine values in the context of their work legacy. This paper suggests that students can learn to examine values in the context of poetry about technology and work. Sample themes and readings illustrate how poetry, and other art forms, teach about the history of technology and work, and provide ethical alternatives.

The arts can provide a vehicle for taking a scholarly, if not a nostalgic, look backwards in order to facilitate a look into the future. It is noteworthy that the turn of a century is less than 4,000 days away--a mere moment in the history of time.

WORK VALUES: PLOW TO ROBOT

Truly, poets and artists have historically pointed to society's problems and have become a signal of change. Edwin Markham's poem "The Man with the Hoe" is a fine example. Seeing Millet's powerful and sad painting of a bowed, broken worker, Markham made this peasant a symbol of all workers. At the turn of the last century (1899), this poem became a rallying cry against the exploitation of labor.

> Bowed by the weight of centuries he leans
> Upon his hoe and gazes on the ground
> The emptiness of ages in his face.
> And on his back the burden of the world.
> Who made him dead to rapture and despair,
> A thing that grieves not and that never hopes,
> Stolid and stunned, a brother to the ox?
> (Markham, 1940)

"A brother to the ox?" No more! Those involved with modern technology, whether in factory automation, farm machinery, or home use, see an end to the mindless, demeaning work that should be left to oxen--or machines.

And what might humans do with the new leisure when they become truly human? Again the poet points the way. Markham continues:

> Is this the Thing the Lord God made and gave
> To have dominion over sea and land;
> To trace the stars and search the heavens for power;
> To feel the passion of Eternity?

"To trace the stars and search the heavens"--a joy for astronaut or philosopher. "To feel the passion of Eternity"--a joy for physicist or poet.

The worker on an unemployment line in Detroit or Pittsburgh may not see the new freedom from behaving like an ox in totally positive terms. The promise that millions of American jobs may be performed by robots does not make the freedom of leisure a great joy. A look at history may, however, give a new perspective.

Fifty-five years ago, this country experienced a great industrial reorientation and economic agony which caused people to question the foundations of capitalism. But out of that economic spasm known as the Great Depression came the 40-hour week, a strong labor movement, and with it some basic human rights.

Now as we pass through another industrial shift and another economic agony, we can begin to see outcomes which may include a 32 hour work week, more human rights, and the intelligent, humane use of leisure time.

But back to early literature:

> In the sweat of thy face shalt thou eat bread. (Genesis)

"Six days shall you labor...." Biblical quotations abound and have set parameters of our values toward work. Is work an enriching experience or is it humanity's punishment for the sins of Adam and Eve? One's response to that question will focus one's values toward labor-saving tools--robots specifically and automation in general.

The ancient Hebrews saw work as painful drudgery. The later rabbinic era tried to cast a glow of wholesomeness on work, yet promised the reward of a kingdom of idleness. Early Christianity also viewed work as punishment for sin. Luther, in contrast, saw work as central to life and mocked idleness as unnatural. Calvin, like several other Protestant theologians, insisted that work is good because it is God's will.

This too simplistic examination of religious views of work clearly suggests a diversity of leads for students as they explore their own values about an activity which is central to western civilization.

The ancient Greeks saw man as brutalized by work and developed a separate class of being--slaves--to provide labor. Karl Marx, on the other hand, saw meaning in productive labor as the "first necessity in life." His concern was with the quality of the worker's experience while earning a living. And so as modern machinery took "meaning" from work, especially the crafts, Mills wrote:

> As practice, craftsmanship has largely been trivialized into "hobbies," part of leisure, not of work. (Mills, 1953)

While there are those who assert that work can cleanse the soul, rhyme generally favors the other position. Galbraith opens his chapter "Of Toil" with the "traditional epitaph of an English charwoman":

> Don't mourn for me, friends, don't
> weep for me never,
> For I'm going to do nothing forever
> and ever (Galbraith, 1971).

Less cheerful and more political is Thomas Hood's nineteenth century poem "The Song of the Shirt."

With fingers weary and worn,
    With eyelids heavy and red,
A woman sat in unwomanly rags,
    Plying her needle and thread,--
        Stitch--stitch--stitch!
In poverty, hunger, and dirt;
    And still with a voice of dolorous pitch
She sang the "Song of the Shirt!"

"Work--work--work
    While the cock is crowing aloof!
And work--work--work
    Till the stars shine through the roof!
It's oh! to be a slave
    Along with the barbarous Turk,
Where woman has never a soul to save,
    If this is Christian work! (Hood, 1948)

Nine more stanzas examine work with its hardships and poor rewards. A student project might pair this and similar poems with a history of worker responses to machinery. Especially poignant is the story of the Luddites (1811-1816), who destroyed early steam-driven machinery because they feared the total unemployment of weavers.

The "Liberal Age" produced Keats' "Isabella" and Ernest Jones' "The Song of the Wage-Slave," both of which examine "oppression" of workers. William Morris' "The March of the Workers" calls for revolution.

Many a hundred years passed over have they labored
    deaf and blind;
Never tidings reached their sorrow, never hope their
    toil might find.
Now at last they've heard and hear it, and the cry
    comes down the wind;
And their feet are marching on. (Morris, 1948)

What changes in technology brought about this liberal age, this defense of the oppressed worker? How fascinating an opportunity for students to study technology, industrial history, economics, religion, poetry, even work songs--all in an integrated unit. And perhaps stir in a little political history with Eugene Pottier's poem, subsequently set to music, "The International." Most recognize the first words: "Arise, ye pris'ners of starvation!/ Arise, ye wretched of the earth,"; few know the powerful ending:

Toilers from shops and fields united,
    The party we of all who work;
The earth belongs to us, the people,
    No room here for the shirk!
How many on our flesh have fattened!
    But if the noisome birds of prey
Shall vanish from the sky some morning,
    The blessed sunlight still will stay.

'Tis the final conflict,
    Let each stand in his place,
he International Party
    Shall be the human race. (Pottier, 1948)

It is noteworthy that the American Communist Party, like several other radical American movements, opposes the introduction of industrial robots into the modern factory. The current fear, like that of the nineteenth-century Luddites mentioned earlier, is that the "toilers" will be unemployed and starving. Work has new meaning for radical movements.

Or one might study the American labor movement beginning with Millet's famous painting of "The Man with The Hoe" and Markham's subsequent poem which was cited earlier. More political than Millet's painting, and perhaps more dramatic, is Ford Madox Brown's "Work." Painted circa 1860, it reflects the anger of some of the poems cited here. Anti-capitalist in tone, it shows four proud street workers digging in a London street. One sees "ladies" and "gentlemen" in the background and, significantly, Thomas Carlyle as an observer of the street scene. It was Carlyle, of course, who celebrated the workingman while thundering against "mammon worship" (Briggs, 1970).

WOMEN'S WORK

The impact of technology on industry and the modern office has affected "women's work" and that too is a potential theme for study. "The Song of the Shirt," cited previously, spoke of early nineteenth-century sewing shops before the invention of the sewing machine (and certainly before automated clothing factories). The fourth stanza is especially relevant.

"O men with sisters dear!
    O men with mothers and wives!
It is not linen you're wearing out,
    But human creatures' lives!
        Stitch--stitch--stitch,
    In poverty, hunger and dirt,--
Sewing at once, with a double thread,
    A shroud as well as a shirt!
     (Hood, 1948)

C. Wright Mills, while discussing changes in office work, provides a unique reading list:

> Novels about white collar girls, appearing mainly in the 'twenties, were very popular. Kitty Foyle's time is from 1911 through the middle 'thirties; Minnie Hutzler, another Morley character in Human Beings, is followed from 1889 to 1929; the story of Janey Williams of Dos Passos' USA runs from 1900 to 1920; Tarkington's Alice Adams and Sinclair Lewis' Una Golden lived before World War I. (Mills, 1953)

Sinclair Lewis' The Job, published in 1917, is not only an interesting examination of office work, but also one of the earlier examinations of women's aspirations. At the end of the novel, Walter suddenly finds himself supervised by Goldie.

> "Gee!" [he says] "I can't go on working for you. The problem of any man working for a woman boss is hard enough. He's always wanting to give her advice and be superior, and yet he has to take her orders." (Lewis, 1917)

When Walter proposes marriage, Goldie responds, "But, my dear boy, I'm a business woman." I won't give the ending away here!

The Job, like many other novels, along with a study of poetry, philosophy, theology, history, economics--the humanities as well as the social sciences--can give some insight into our values about work in a context of technology.

BACK TO THE FUTURE: ROBOTS AND OTHER AUTOMATION

The flourishing of culture in ancient Athens was made possible by a slave class which was essentially invisible. Slavery was rarely referred to and consequently "did not exist." Slaves apparently were looked on as machines and, to this day, there is not much information regarding the size of the slave population--although there were probably enormous numbers of them. Perhaps citizens of the twenty-first century can one day, like the citizens of ancient Athens, devote themselves to the pursuit of beauty and truth supported by the work of a new slave class--robots.

Are we all robots (Cohen,1978)? The question is not idle and our answer strongly reflects our philosophy of life--and our theology. The biblical story of creation reflects earlier answers to the question. We are told that we were purposely "created" by a superior being. James Weldon Johnson paints an interesting picture which includes the magic of the "breath of life."

Up from the bed of the river
God scooped the clay;
And by the bank of the river
He kneeled Him down;
And there the great God Almighty,
Who lit the sky and fixed it in the sky,
Who flung the stars to the most far corners of the night,
Who rounded the earth in the middle of His hand--
This Great God,
Like a mammy bending over her baby,
Kneeled down in the dust
Toiling over a lump of clay
Till He shaped it in His own image;
Then into it He blew the breath of life,
And man became a living soul.
Amen. Amen. (Johnson, 1950)

Using Genesis as our model, we create creatures "in our own image" for our own purposes. One of the more popular is the Golem, allegedly created by Elijah of Chelm (c. 1550). The word "Golem" is used in Talmudic writings to describe one of the stages of Adam's creation. Since then Jewish communities in Poland and Russia have periodically reported the existence of Golems, some of which helped protect the community against anti-semitic invaders. Gustav Meyrink's German novel The Golem (1915) describes an "automatic man" who helps ring the bells of the Synagogue and who does other labor. In this version the rabbi temporarily loses control of the Golem and it runs through the streets becoming a threat to the community. (Meyrink, 1928)

Goethe's Faust includes a synthetic life form known as "Homunculus" and, of course, Mary Wollstonecraft Shelley created Dr. Frankenstein's monster, who forces us to examine the ethics of the creator and the created--as "monster" is created in man's image.

> I saw the hideous phantasm of a man stretched out, and then, on the working of some powerful engine, show signs of life, and stir with an uneasy, half-vital motion. Frightful must it be; for supremely frightful would be the effect of any human endeavour to mock the stupendous mechanism of the Creator of the world. (Shelley, 1974)

A course choosing to examine cultural perceptions of robots might turn to theater, especially Karel Capek's 1920 drama, R.U.R., which is cited as one of the first uses of the word "robot." In this Czech play, the robots organize and rebel much as factory workers might.

Movies, too, examine robots. Two German films lead the list and can be used to stimulate classroom discussion. The Golem (from the novel discussed earlier) portrays an artificial being as a monster. Metropolis" the 1925 Fritz Lang film, continues to be popular because of its artistic qualities and because it examines significant social issues. It may be the first to show a female robot. Perhaps most appropriate for modern college audiences is Charlie Chaplin's Modern Times because it examines the whole issue of industrial automation, including human/machine relationships, and because it is just plain fun.

Choosing educational materials for an exploration of the impact of automation on modern society can be an exciting experience. From Asimov to Vonnegut the literature surrounds us. Indeed, we are surrounded by the experience of modern social values. Perhaps for that reason we must step back, sample some of our experiences, and discuss them as outsiders. We must become participant/observers.

Asimov's latest examination of the impact of worker robots makes for enjoyable student reading because it is couched in a science fiction mystery. Nevertheless, serious questions emerge.

> "On the planet there are fifty robots to each human being on the average....Most...are on our farms, in our mines, in our factories, in space. If anything, we suffer from a shortage of robots, particularly of household robots. Most Aurorans make do with two or three such robots, some with only one...."
>
> "How many human beings have no household robots at all?"
>
> "None at all. That would not be in the public interest. If a human being, for any reason, could not afford a robot, he or she would be granted one which would be maintained, if necessary, at public expense. (Asimov, 1983)

Or Kurt Vonnegut's novel Player Piano provides a "funny and savage" examination of industrial automation. From the back cover:

> Want the computer to solve all your problems? Want machines to give you everything you need? Want to be taken care of from cradle to grave by an industrial society that knows what is good for you? (Vonnegut, 1980)

Occasionally the perception of human as worker who is potential monster takes political form. In 1970, Roger Freeman, President Nixon's key education advisor, stated:

> We are in danger of producing an educated proletariat. That's dynamite! We have to be selective as to who we allow to go through higher education. (Carlin, 1984)

Freeman goes on to explain that such an educated proletariat could be dangerous in times of crisis "because they wouldn't automatically and unquestionably follow the orders of their leaders and bosses."

EPILOGUE

The program proposed here permits students to examine their lives in a technologically advanced society. They are given a chance to examine the roots of the physical, social, and cultural environment in which they live. Sample issues and readings have been suggested so that the teacher has leads and perspective in designing a course or program.

Specifically, the themes of this proposed program focus on the world of work--a theme central to western civilization. Students generally appear in our courses as they are preparing for a lifetime of work. Indirectly this program provides such students an opportunity to look "inward" as well as "around" and "out." Perhaps their career choices as well as their work styles and work ethics will be influenced.

Missing in this proposal is a science component. The science or engineering curriculum needs only to integrate some of the issues suggested here. Liberal arts and business curricula, however, need the integration of a science component. But that is a topic for another article.

Central to this proposal is the fact that our students will be making moral choices. Whether as scientists, entrepreneurs, government officials, or simply as citizens our students will be faced with moral dilemmas. Will they have the knowledge and wisdom to make appropriate choices?

Jacques Cousteau describes a situation relevant to scientists everywhere. He writes that the "moral dilemma which faced me each time I even briefly crossed paths with science must have meant agony for those who have made discoveries much more important than ours." In 1957 Cousteau presented evidence of salt domes at the bottom of the Mediterranean Sea. Further exploration of these domes with their potential of trapped oil threatened the destruction of flora and fauna--even oil slicks.

> What had we done by presenting our discovery? I was torn between remorse--thinking that oil-company technicians might ignore the risks involved in drilling deep into the Mediterranean--and pride at having contributed to a better understanding of marine geology. Yet while it was true that our discovery could lead to serious consequences, did we have the right to not reveal what we had discovered?... We cannot stress enough the importance of this gap between science and citizen for which there is no simple solution. Yet one thing is certain: apathy does nothing but feed mistrust. We must first of all dismiss the idea that science is too difficult to understand, too mysterious, that the scientific elite is too erudite to be questioned. (Cousteau, 1985)

A statement often attributed to Peter Drucker reminds us that "the best way to create the future is to create it." Along the way moral dilemmas, like that posed by Cousteau, must be faced and decisions must be made.

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READING, THINKING, AND STS

Mary M. Dupuis

Introduction

Reading issues intersect with the teaching of Science and STS materials in several specific ways. Fundamental to reading, as to STS learning, is the concept of metacognition. The term metacognition, as it applies to reading, refers to "the knowledge learners have about reading strategies and the ability to capitalize upon such knowledge to monitor their own reading" (Vacca and Vacca 1986, p. 254; and Tierney 1982). A metacognitive approach to reading instruction implies a self-aware and active role for the learner as a generator of knowledge. Students' prior knowledge, their attitudes toward reading, and their ability to synthesize or integrate new learning with prior knowledge are as important in reading as in science/STS instruction. Our primary concern must be student comprehension of the material selected by the student or teacher for reading. A second concern is the use of reading materials for concept development in the context of the Science/STS curriculum. A third concern is the analysis of materials for problems of text difficulty and readability, patterns of text development, and suitability of the text for urban or minority students.

Metacognition and Independent Reading

Reading in Science and STS is characterized by the discovery of meaning and knowledge through the study of written material. Reading instruction in science means "to teach simultaneously the science content and the reading and reasoning process by which that content is learned" (Thelen, 1984, foreword).

A reader makes sense of texts by using both background knowledge and expectations about and interactions with written language. This interaction between reader and text is a process largely controlled by the reader. It is the teacher's role to facilitate this interaction. Reading should not be considered as a set of separate skills, but as a process by which students acquire information, think about what they read, and use what they have read.

The ability to read independently is especially important in the secondary years, since very little class time is devoted specifically to reading, yet texts are still the basic sources of information (Alvermann, Conley, and Moore, 1986). In independent reading, readers control their own learning. The teacher provides support and guides progress towards independent learning by asking questions, giving demonstrations, providing guide materials and prereading strategies, and so on. The teacher's task is to show the students not what to learn but how to learn, how to investigate and interpret a text effectively. This independent reading will enable students to read independently as required in STS at the level of issue investigation. The search for background information and the synthesis of that information with data developed by independent investigations will allow students to develop STS action plans (Rubba and Weisenmayer, 1988).

To achieve independent learning, students must make a gradual transition from teacher-centered guidance to self-control and self-monitoring of their own reading and studying. Prerequisites for independent learning are knowledge and awareness of the reading process.

A student who is able to monitor his or her own reading approaches a text assignment by 1) analyzing the task, reflecting upon what he or she does and doesn't know about the material; 2) making plans for reading; 3) using strategies suited to his or her purpose for studying the particular text. Such students recognize whether they have problems with a particular text selection and why. By using appropriate reading and study strategies, they can solve such problems.

Characteristics of Texts

Text Structure

Although comprehension of texts is strongly influenced by the students' prior knowledge and experience, texts nevertheless have a particular structure separate from the student's cognitive structure. It is especially important to examine characteristics of texts because written materials occupy a dominant place in science and STS instruction. Textbooks in particular play a central organizing role in science instruction, although STS encourages the selection of other written materials to supplement text books, e.g. current newspapers and magazine articles.

Thelen (1984) remarks that science teachers often complain that their students cannot read the textbook and don't learn from it. This does not mean that the use of textbooks should be abandoned. Instead, it should be recognized that textbooks are important means for increasing knowledge and understanding, gaining new insights, and sharing the experiences and feelings of others (Dupuis, et al., 1989). Sometimes the reading problem stems from a mismatch between the students' reading abilities and the readability level of a text. Reading problems at the secondary level are usually not related to deciphering the text but to understanding its message (Alvermann, Conley, and Moore, 1986).

Little effective independent learning arises from most secondary content texts, according to Tierney (1982). However, since most science instruction in class is based on oral presentations and most of the reading is done outside of class, the ability to read independently is of utmost importance for the student (Alvermann, Conley, and Moore, 1986). Students must be able to analyze texts in order to understand their potential use as effective tools in an independent learning strategy. The text being used might contribute to the students' development of self-monitoring abilities. Making judgments about a text depends also upon its intended function. For example, is it the primary source of information? Is it supplementary or used as a reference? Is it a source of uncontested facts and concepts, or is it a statement of one among several possible positions?

The structure of a text refers to a "hierarchical arrangement of sentences and paragraphs within a large piece of text" (Alvermann, Conley, and Moore 1986, p. 64). Authors impose a structure on their presentation of ideas. Students' ability to recognize the different types of structures used in science texts and other reading materials is the key to comprehending and retaining the ideas (Niles, 1964; Meyer and Rice 1984; and Vacca and Vacca, 1986).

External structural features of texts are important cues for comprehending their overall design. The reader should first examine the preface, the table of contents, the bibliography, and such. Within each chapter, the reader should look at the introduction, the headings, the graphs, and the summary as indicators of the structure of a text.

The internal organization of a text refers to the interrelationships among important and less important ideas. Science textbooks can be classified as expository texts, since the primary form of discourse is the presentation of information. Different patterns of logical connections exist among the ideas (Meyer, 1975).

Herber (1978) distinguishes among four organizational patterns (or top-level structures) found in expository texts.

1. enumeration: information is simply listed. The author does not indicate logical connections among sentences, facts, characteristics, etc. This pattern is found most frequently in textbooks (Vacca and Vacca, 1986). Words that signal this pattern are to begin with ... first ..., second ...; ... follow:

2. time order: a sequential relationship exists among the ideas, indicated by signal words, such as on (date), not long after, now, and when.

3. comparison-contrast: the likeness or differences among facts, people, events, or concepts are presented. Signal words for this organization pattern are however, but, on the other hand, but also, similarly.

4. cause-effect: the author indicates how facts, events, or concepts (effects) happen or came into being as a reaction to other facts, events, or concepts (causes). Signal words include because, since, nevertheless, accordingly, and is ... then.

Vacca and Vacca (1986) add problem-solution as a fifth top-level structure. A problem is developed and followed by its solution(s); this is a special case of the cause-effect pattern. These five patterns can be combined in a complex way (for a more complete description and examples, see Herber, 1978, Meyer, 1975, and Vacca and Vacca, 1986). Knowing the structure of texts helps the student to follow the authors' thoughts, to discover meaningful relationships among important and less important ideas, and to retain what they have read (Alvermann, Conley, and Moore, 1986).

Alvermann, Conley, and Moore (1986) describe four criteria by which one can access the degree of "considerateness" of a text. A considerate text makes learning form written material easier.

The four criteria are:

1. structure: a plan for how ideas are arranged and connected;
2. coherence: clarity of relationships among ideas, within and across sentences and paragraphs;
3. audience appropriateness: a good match between readers' knowledge and what the text is teaching.
4. unity: the degree to which only relevant information is included to support an author's assumed purpose.

Readability and Difficulty

To evaluate a text one must assess its readability level. Readability refers to "the ease of understanding of a text chiefly because of features of writing style" (Alvermann, et al., 1986, p. 47). Although the students' interests, background knowledge, and motivation have an important effect on their success in learning from a text, a prerequisite is a level of difficulty that is appropriate to their abilities.

Vacca and Vacca (1986) make a distinction between a qualitative ("professional judgment") and a quantitative analysis of the readability level of a text. They present an adaptation of the Irwin and Davis Readability Checklist (1980), which focuses on the understandability, usability, and interestability of texts (p. 41, ff). Understandability refers to the potential match between what a particular group of readers knows and the presented information. Usability relates to the way the content is presented and organized. Important issues here are coherence, unity, and structure (Alvermann, Conley, and Moore, 1986). The interestability of a text refers to whether the features of a text appeal to a given group of students.

Understandability and interestability are particularly important criteria for minority students, who may have experiences and knowledge that are culturally different from the majority. For example, textbooks usually don't have illustrations and pictures that show people similar to themselves.

The use of formulas for assessing readability of textbooks has received a lot of attention. Attempts to improve comprehension by matching readability scores of a text with the student's reading ability are limited. The formulas don't deal with the prior knowledge and experiences of the students (for example, emotional, cognitive, and linguistic backgrounds). In addition, such formulas are usually based on sentence length and the complexity of words, while long sentences, rated as more difficult, may provide clues for their interpretation that make them easy to understand (Dupuis, et al., 1989). Also students exhibit a wide range of reading ability, a range which increases every school year (Alvermann, Conley, and Moore, 1986). However, for the teacher who is aware of their limitations, a readability formula may provide a useful rule of thumb.

Minority Issues and Language Differences

Inclusion of Minority Issues/People

Minority students may encounter particular problems in studying science texts. Texts are written for a preconceived audience. Minority students may not be considered explicitly as an important and distinct part of this audience. In addition, the author's view of reality may not be readily recognizable for many inner-city minority students. Conversely, the students' views of reality may not be reflected in any assigned or recommended reading materials in science class. Throughout the literature on reading in science, writers stress that background knowledge, experience, and attitudes are significant factors in reading comprehension. What are often perceived as black students' reading failures may be more deeply rooted in their views of reality and perceptions of themselves from cultural and historical perspectives (Chaplin, 1985). When new information does not conform to existing perceptions, it may be reconstructed or rejected.

Blacks have often perceived that they are considered inferior with respect to their experiences, language, and socio-economic status. Appropriate secondary science textbooks and curriculum materials, based upon situations, events, and persons with which minority students can identify, may be hard to get. Teachers have the task of bridging the gap between text and experience.

As things now stand, school experiences often promote for minority students a negative perception of themselves in general and of their reading abilities in particular. This suggests that teachers need to adopt strategies which assist students in building confidence in their abilities and to recognize the students' internal capacities, separate from their current behavior or scores on standardized tests.

A feeling of power to control the text is essential for comprehension. Trout and Crawley (1985) report research findings on students who feel they have little control over their fates. The instructional strategy that develops a more positive student attitude in science includes frequent teacher-student interaction, a high rate of arbitrary instead of task-dependent reinforcement, and a fixed structure within the learning situation. Knowledge and awareness of the reading process and the ability to regulate their own reading are crucial for minority students. The idea of metacognition, as explained in the first part of this paper, and the teaching and study strategies based on this idea are highly applicable to science reading for minorities.

Problems of Language Differences

Any dialect or variety of a particular language is a product of culture, environment, the needs of the group, and contact with other languages (Alexander, 1985). Although Black English differs from 'media' English in some phonological, syntactic, and lexical features, research suggests that these differences do not interfere with reading comprehension, except that they create some confusion in beginning reading programs (Weaver and Shonkoff, 1978). Weaver and Shonkoff ascribe the perceived reading problems of black students to the attitudes of teachers who come from a cultural and socio-economic background different from that of their minority students. They state that teachers' attitudes and expectations have a negative impact on students' motivation and performance, which may interfere with reading. Rather than diagnosing black students as disabled, teachers must display a positive approach to teaching black students. They must convey to their students that a dialect is not an inferior form of language and must recognize that dialect *per se* is unlikely to interfere with reading. In addition, teachers must know the features of the nonstandard dialect so that "errors" are not interpreted as reading or comprehension problems.

The authors of essays in Tapping Potential: English and Language Arts for the Black Learner (Brooks, 1985) convey clearly that the basic issue regarding the reading problems of black students lies in the misunderstanding of language differences. Respect for individual differences is essential, because "to deny the student's language is to deny the student" (Perry, 1985).

Turner (1985) does away with several myths about black English, such as these:

1. There is one black English. (In fact, Blacks speak many varieties of black English.)
2. Dialects lack the vocabulary for precise thinking and understanding.
3. Black students hear in black English, so they spell in black English. (If this were the case, Bostonians, for example, would write "Baston." Also, English is not a phonetic language: compare, for example, the spelling of proceed, precede, and supersede. Turner's conclusion is that no single approach is suitable for teaching all black children. He admits that he is not able to resolve the question of whether to teach standard English or whether to urge bidialecticalism.)

Finch (1985) provides practical tips for teachers who work with learners who speak several dialects. Communications between student and teacher and among students can be fostered when teachers are willing to understand different dialects and to show respect for differences. The teacher's ultimate goal is for students to achieve proficiency in the use of standard English.

Lack of motivation is considered by many educators to be the main reason for inner city children's problems in learning and reading. Cureton (1985) acknowledges the importance of discovering each individual's learning style. Learning style refers to the most comfortable manner of learning (for example, visual or auditory, independent or group). If the teacher uses an individual's strengths, he or she may be able to raise the student's motivation. Cureton refers to research on cognitive style mapping, which shows that inner-city children learn more effectively when physical and oral involvement are present.

Comprehension and Strategies

Importance of Prior Knowledge to Reading Comprehension

Background Knowledge. As has been stressed before, students' prior knowledge and attitudes have a great impact on their comprehension of the text.

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Recently, researchers have paid increasing attention to background knowledge, partially because of the popularity of a "schema" approach to reading. A schema "is used to represent information that is stored in an organized way in your memory and that is based on your repeated encounters with a particular person, place, thing, or event in the past" (Alvermann, et al., 1986, p. 70). Several schema inadequacies can interfere with reading comprehension.

1. Schema unavailability refers to a lack of relevant background knowledge and information needed for understanding a text assignment.

2. Schema selection refers to the case where sufficient background knowledge is available, but the student is not able to activate it.

3. Schema maintenance means that "students may not be aware or skilled enough at recognizing when shifts in schema occur during reading" (Alvermann, et al., 1986, p. 70).

A related problem is that students may have their own "theories" about scientific phenomena which interfere with a meaningful understanding of the science concepts presented in textbooks. These naive theories have been developed over the years from the student's everyday experiences (Vacca and Vacca, 1986).

Assessment of schema qualities helps the teacher to make decisions about, for example, the amount of prereading preparation students will need and how much background building will be necessary. One strategy involves constructing a background knowledge inventory according to the major ideas and concepts to be studied. The outcome of this inventory should be discussed with the students to introduce them to the major concepts they will need (Vacca and Vacca, 1986; Alvermann, et al., 1986).

A more formal procedure is the PreP (Prereading Plan), which encourages group discussion and an awareness of the topics to be covered (Langer, 1981). The teacher determines the key words, phrases, or pictures in the text that represent the major concepts. In three phases, he or she introduces the topic to groups of ten students:

1. discover the students' initial associations with the concept;

2. students to reflect on their initial associations;

3. reformulate their knowledge based on the discussion.

By observing and listening, teachers can clarify their students' background knowledge and focus their instruction accordingly. Through such assessment strategies, students' prior knowledge that conflicts with or is culturally different from the text may become apparent.

Instructional Strategies

Once the teacher has assessed background knowledge and attitudes, he or she can select instructional strategies and adapt them for particular subjects, schools, and classrooms.

Prereading Strategies. Prereading preparation is an often neglected area of science teaching (Thelen, 1984; Vacca and Vacca, 1986; Vaughan, 1982). When students study new material without having background knowledge, they tend to memorize. Thelen (1984) argues that students have often learned through experience that memorization leads to correct answers. In addition, certain teachers tend to encourage rote memorization by giving little credit to substantially correct answers that do not correspond verbatim to the text. Rote learning is also an alternative for students whose anxiety level is high or who lack confidence in their ability to learn meaningfully.

Prereading instruction can be connected with two principles: the feed-forward effect and cognitive readiness. 'Feed-forward' refers to the reader's anticipation of what will be learned through written materials (Stauffer, 1975). The questions "What do I need to know?" and "How well do I already know it?" help readers to reflect on their knowledge, to make predictions, and to set goals. The ability to ask these questions and to reflect upon them requires metacognitive awareness. Cognitive readiness refers to "the ability of a learner at a given age to cope adequately with the demands of a given task" (Ausubel, et al. 1978, in Vacca and Vacca, 1986, p. 101). The most important function of prereading strategies is to prepare students to be confident and to think positively about what they will encounter in text assignments. Various types of advance organizers are widely used, from concept mapping to structured overviews. These may be teacher or student generated. Brainstorming and creating conceptual conflicts are ways to stimulate students' curiosity. Prediction strategies, such as student-generated questions and anticipation guides, can help students activate prior knowledge. (For specific techniques, see Dupuis, et al., 1989; Vacca and Vacca, 1986; Thelen, 1984; Herber, 1978).

Strategies During Reading

While the ultimate purpose of science reading is to show students how to learn independently from texts, many students need some guidance in dealing with the conceptual demands of texts.

Reading or study guides are teacher-constructed adjunct instructional materials meant to provide support for students as they form concepts. These guides are an essential tool for maturing readers who need modeling and guidance learning why, when, and how to read. Herber (1978) maintains that reading and study guides simplify difficult text for readers. A distinction can be made between interlocking and non-interlocking guides. An interlocking guide assumes a hierarchical relationship from the level of literal through interpretive to applied comprehension. Non-interlocking guides require students to search for relationships while reading, switching among the different levels.

Postreading Strategies

Comprehension of the content can be reinforced by postreading review and reflection. Research indicates that *postreading questioning* in the form of application or inference questions is likely to facilitate learning (Vaughan, 1982). Several authors report a lack of research on specific issues related to postreading questioning, such as the effect of text-type and pertinent feedback.

Another activity intended to facilitate postreading recall involves Manzo's (1975) *guided reading procedure*. Based on what the students remember, the teacher guides the students in modeling the process of organizing and associating concepts. This strategy is more effective when used in combination with prereading activities (Vaughan, 1982).

For the purpose of independent learning, *student-directed activities* are more appropriate. An example is the *graphic postorganizer*, which is used similarly to the advance organizer. *Semantic mapping* may be used as another student-directed postreading strategy.

Herber (1978) emphasizes the importance of postreading and nonprint-related reasoning. In order to foster independent reasoning, students should be taught *how* to apply the reasoning process effectively. He recommends a functional approach in which the reasoning process is simplified, but not fragmented into subskills. How to simplify reasoning for teaching purposes is not quite clear, but Herber makes an attempt by making a basic distinction between open and closed reasoning to replace the seven distinctions he found in the literature.

Vocabulary and Concept Development

Vocabulary studies in content areas often focus on the acquisition and expansion of word definitions and word meanings. However, reading comprehension also requires an understanding of how terms relate to one another conceptually and how terms are defined by the context of the reading passage. Concept development is the appropriate framework within which vocabulary should be taught and reinforced. Herber (1978) uses the term *vocabulary development* to capture both vocabulary and concept development in the content areas. He uses Goodman's definition (1970): "vocabulary development is the ability of the child to sort out his experiences and concepts in relation to words and phrases in the context of what he is reading" (p. 133). The distinction between a word and a concept is characterized by Vacca and Vacca (1986) as representing more than the meaning of a single word. Concepts provide in short form what it might take many words to describe. Concepts are mental images that mostly represent a general class linked by common characteristics. Concepts are learned best by manipulative, purposeful experiences, while in content material, students are confronted with many special and technical words that don't have concrete referents (Dupuis and Snyder, 1983).

Vocabulary development, especially concept labeling, is an important component of STS Foundation, Level I of the STS Goal Hierarchy (Rubba and Weisenmayer, 1988). The definitions of scientific terminology and the relationships among concept labels will require careful instruction. Minority students will need practice in working with the terminology and becoming comfortable with it. Only when students are comfortable with language can they use it to assess multiple viewpoints, develop problem-solving procedures, and make reasonable decisions.

Instructional strategies should emphasize 1) reinforcing of word meanings and conceptual relationships, 2) developing of inquiry skills that help the student to determine the meanings of unfamiliar words they encounter, and 3) awareness of and excitement for learning new words.

Content areas are distinguishable by their particular vocabulary. Any content area text will contain three types of vocabulary: 1) a general vocabulary that consists of everyday words having widely acknowledged meanings, 2) a special vocabulary in which everyday vocabulary takes on a meaning adapted to a particular content area, and 3) a technical vocabulary that is used and applied only in a particular content area (Vacca and Vacca, 1986; Dupuis et al., 1989; Dupuis and Snyder, 1983).

Vocabulary Reinforcement and Extension

Reinforcement activities may take place either before or after reading. Vocabulary exercises should not only reinforce definitions but should also help students to manipulate words in relation to other words.

Henry (1974) associates four basic cognitive operations with learning concepts and words.

1. the act of joining or "bringing together," which enables the students to compare, clarify, and generalize;
2. the act of excluding through which examples can be distinguished from nonexamples of a concept;
3. the act of selecting through which students make choices and "explain why based on what they experience, know or understand" (Vacca and Vacca, 1986, p. 311);
4. the act of implying which refers to the ability to make decisions based on if-then, cause-effect relations among concepts and words.

Activities which help develop relationships among concepts include word sorts, categorization exercises, and analogies. Context is the basis of close exercises and many word puzzles. Word attack skills such as structural analysis (root-prefix-suffix), use of context clues and use of the dictionary also help develop vocabulary. (For specifics on these techniques, see Dupuis, et al., 1989; Vacca and Vacca, 1986; Dupuis and Snyder, 1983; Henry, 1974).

Summary and Conclusions

The issues of metacognition, prior knowledge, transfer of skills, and the synthesis and integration of knowledge are all important bases for responses to problems of reading in Science/STS. A great deal is known about reading in content areas and a surprising amount of that work has dealt with reading in science. The importance of cognitive and concept-oriented instruction of science is well-known; hence, most of the strategies presented here are cognitive. Teachers can develop a broad repertoire of instructional strategies for reading in science, including vocabulary work, study guides, comprehension, study skills, and independent learning.

When we look at affective or attitude issues, science reading has also received serious study. Clearly students' background, past success, level of aspiration, interest in the material, and achievement will affect their attitudes toward reading. When students come from minority cultures, concerns for language and cultural differences compound these affective variables. We must be careful to consider these variables as we plan the Science and STS curriculum. The STS goal of awareness which leads to action requires that we work to develop positive attitudes toward the use of language and reading as tools for effective living.

Teachers who focus on Science and STS instruction can respond to and accommodate students' reading needs while they retain their central focus on the content of the Science and STS curriculum.

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TEACHING LITERATURE: SCIENCE/HUMANITIES

Edward R. Fagan

Science, Technology, and Society's (STS) (1985) concerns for bonding across C.P. Snow's (1962) "two cultures," the science and the humanities, prompted me to design a course arbitrarily labeled Literature through Science. The course was designed for senior high school students enrolled in Pennsylvania's State College Area School District's Alternative Program (AP). Enrollment was to be voluntary and the course was to be housed with the English/Humanities program. To offer such a course, a complete outline of its contents, objectives, time frame (length of class, number of weeks in the course) plus examples of how the course would fulfill conventional English requirements at the primary trait level, that is, grammar, spelling, vocabulary along with the usual expository and creative writing within NCTE guidelines of reading, writing, speaking and listening had to be approved by the Board of Education. The science aspects of the course required approval of the science and art teachers who agreed to cooperate with the program. Those teachers and the Board, after suggesting minor changes in the course outline, gave their approval.

Two sophomores, four juniors, and seventeen seniors volunteered to take the course and, with the parents' endorsements, satisfactorily completed the course within the specified time limits. These students were not "exceptional" except in the fact that they preferred learning situations which offered them more independent responsibilities than those imposed by a traditional 50-minute bell schedule. Learning climates for these AP students can be described as "open" in the sense that students, parents, counselors, administrators tended to make decisions based upon group consensus. In addition, students were also part of a peer group organization defined as a "clump." These clumps operated something like homerooms where routine activities, social events, academic problems and the like were discussed.

The foregoing background about the learning climate in the AP program provides a rationale for some of the contract activities listed as part of students' assignments. Obviously, arrangements had to be made -- sometimes by students, sometimes by teachers in the course -- with community resource people to provide interviews, internships or auditing opportunities (at nearby Penn State University) for AP students working on particular projects with science/humanities links.

Procedures

After reviewing materials to be used in the course -- articles, essays, films, schematic models -- and discussing some of the scientific and artistic vocabulary with other teachers involved with the course, a pretest of that vocabulary was given to the students. Two conditions about this vocabulary pretest should be noted. First, correct identification of a vocabulary word was interpreted as a layman's knowledge of the particular word (entropy, for example) and not necessarily a student's understanding of that word as a scientific concept; second, each scientific concept for a word was checked against definitions from the Dictionary of Science (1969). Similar checks were made for art and humanities vocabulary and concepts.

Pretests were returned to students for their examination, and they were asked to note those vocabulary words which, for them, were unfamiliar. They were told that the course contents would present all of the pretest words within contexts which expanded the surface meaning of the word and involved, in many cases, its use as a scientific concept. The pretests were then collected and students were told that at the end of the course those same words would be used for a posttest.

Extensive writing was done -- creative and expository -- based upon models provided from various genre and in response to contract assignments. The contract assignments permitted students to use other disciplines (science, art, music) as a base for their writing so, in a sense, the course became a prototype of the currently popular writing-across-the curriculum model. Possible assignment topics included: Describe one science concept from the film, "Future Shock" (1980), and define its implications for contemporary life; compare the literary-criticism-as-hypothesis experiment to the science's black box experiment as examples of common problem solving techniques. Examples of contract projects are as follows:

> *Read and react to two selections from the genre you've chosen. Your reaction should explore specific reasons for your positive or negative response to them and should identify the scientific concepts upon which they were based.* (20 pts.)
>
> *Interview a scientist about the contents of a selection from your genre, and report the outcome to the class in a well-organized oral report.* (15 pts.)

In keeping with contract teaching, a series of assignments ranging in difficulty from most to least difficult with appropriate point allotments were available to students with cumulative point allotments determining the lowest letter grade. That is, with 150 total possible points, the lowest A would be 90, B, 80, and C, 70.

At the time that this course was offered (late seventies) Penn State was on a term (ten week) class schedule, and this course was designed to fit that schedule as well as the nine-week marking system for the high school. It was also used to provide prospective English teachers with observation experiences of an interdisciplinary humanities/science teaching model. The course actually ran twelve weeks to accommodate orientation sessions with students and parents.

Outcomes

Of the 49 pretest/posttest vocabulary words, the average numbers of words students correctly identified in the pretest was 12 (24%) but in the posttest 35 (71%). Again, such identification should not be interpreted as knowing the scientific concept as such, but rather knowing the word well enough to define it in popular terms within a scientific context.

Many of the papers and projects generated from the contracts also showed (according to the teachers involved in the project) an "adequate" to "good" grasp of such ideas as entropy, phenotype, antimatter, synergetics, cryonics, homeostasis and the like. Ideas about themes, counterpointing, threnodies, ratios, complementarity, also were discussed from multiple perspectives -- culture, for example, as related to biology, sociology, esthetics, tillage, taste (as in art and music, for example, impressionism or diatonic harmonies, respectively).

Anonymous student evaluations of the course administered by the assigned AP teacher two weeks after the program, showed that all students found the course "interesting," but "difficult." Their evaluations were in response to essay questions about the value of the course to their study of English, Humanities (art/music), science. They felt that course contents were better for the humanities data than for the science -- which I suppose, might be expected even though the science teacher helped to judge the worth of the science contents.

Epilogue

Since the seventies, there has been a geometric growth in scientific information, particularly through technological advances such as the microcomputer, videotape recorder, laser disks and similar swift information dispensers. Books, too, are part of that phenomena with an average of 2,000 books per month coming from presses the world around. Add to the books, magazines, pamphlets, tracts, newspapers, and other forms of graphics and the topic of survival under the media deluge becomes all too real.

What knowledge for what purpose becomes a prime directive in selecting educational information. With the interdisciplinary focus of Science, Technology, and Society (STS) there is a potential for synthesizing the two cultures more efficiently in the public schools. One model for such a synthesis comes from Renner and Stafford's (1979) Teaching Science in the Elementary School (3rd ed.) where they present a consideration for the rational powers of the mind. They note that five of the rational powers of the mind appear to form a chain-like sequence in the logical thinking process. "Those rational powers -- and the sequence -- are recalling, comparing, inferring, generalizing and deducing ... The other rational powers ... seem to be woven into the process of logical thinking to perform their special function when and as needed ... they are classifying, analyzing, synthesizing, evaluating, and imagining" (p. 24).

These rational powers are schematicized by the authors in their Chapter 7, Essential Concepts in Science and, in the first schema for Conceptual Development, match Learning Cycle with Grade Level to produce a figure like the following (196):

Learning Cycle	Conceptual Development	Grade Level
	Things ________Objects	1
Gathering Data	Solids__Liquids__Gases	3

* * * * * *

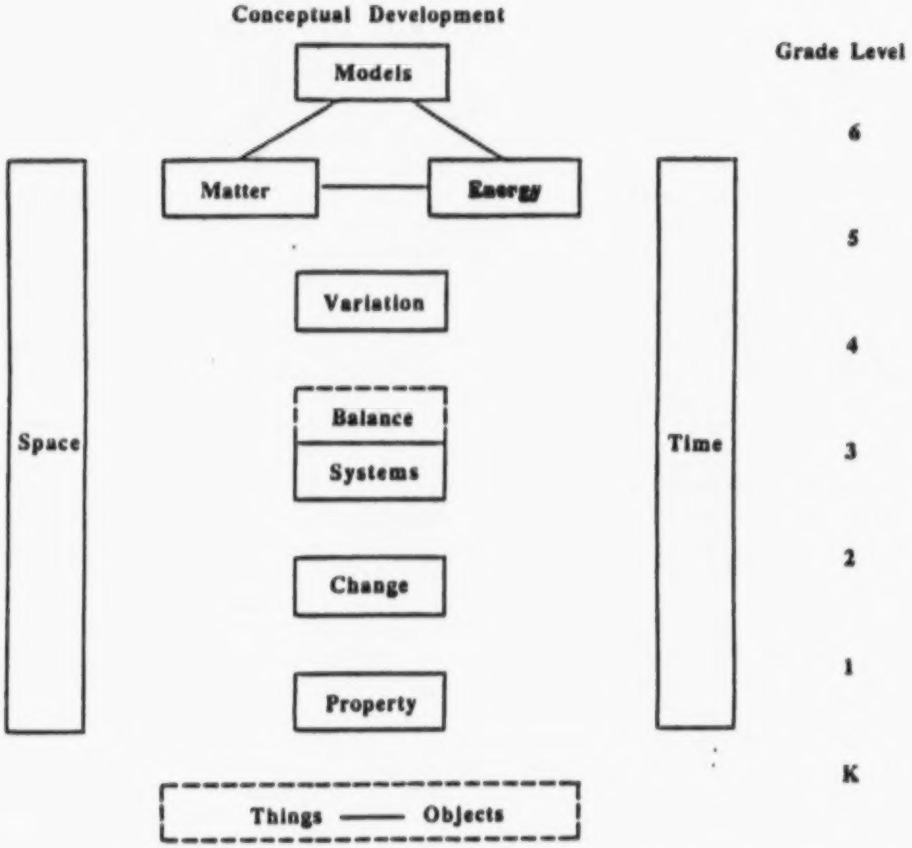
Conceptual Development
Grade Level
Models
Matter
Energy
Variation
Balance
Systems
Change
Property
Things —— Objects
Space
Time
6
5
4
3
2
1
K

Figure 7-3. A conceptual hierarchy must be developed which allows ideas to be presented in a logical order with respect to both content and the child.

Grade 6 in their schema introduces "Models of Matter," and it's that concept which relates to teaching literature through science which I would adapt for the nineties.

As the author's Figure 7-3 illustrates, space and time are key factors in conceptual development models, as they are to any understanding of fundamentals in the study of English/Humanities. All of us could, I'm sure, cite books, films, plays, poems, which illustrate or explore each of the concepts displayed above. More important, the role of space and time in all of that literature is pivotal to our understanding of our personal space in history at this time.

Applications

In working with the contents of Figure 7-3, a teacher or a science humanities team could explore models in various forms and then move to concepts of matter and energy related to the models. From DNA as science source to Robin Cook's book and film Coma (1977) to his more recent book, Mutation (1989), the consequences of genetic engineering could be critically questioned. If classics are part of the required English curriculum, Plato's The Republic (380 B.C.), More's Utopia (1516), or Swift's (1726) Gulliver's Travels are germane. Space and time are parts of these and other selections. Mary Shelley's Frankenstein (1823) explores, through fiction, the "energy/variation" themes also related to the DNA models.

"Balance/systems," also from Figure 7-3, can be explored with ecosystems and A.E. Van Vogt's The Voyage of the Space Beagle (1939) which will then bring in Darwin's explorations and Kate Wilhelm's Where Last the Sweet Birds Sang (1976), this latter a piece of fiction about pollution and cloning in the modern world.

Short stories -- Walter van Tilburg Clark's "The Portable Phonograph" (1941), S.V. Benet's "By the Waters of Babylon" (1937) or Pat Frank's novel Alas, Babylon (1959) deal with "property" from Fig. 7-3 in the sense that death instruments from uranium deterioration and radioactive properties impact on all humanity or, more accurately, the survivors of nuclear wars.

"Things _____Objects" from the Figure bring to mind Karel Capek's play, Rossom's Universal Robots (1921), Huxley's Brave New World (1932), Adams' Watership Down (1954), Orwell's Animal Farm (1946) and Nineteen Eighty-Four (1944), and S.V. Benet's poem "Nightmare Number 3" (1935) where machines revolt against their human masters is an example of still another genre which links science and humanities as is Univac the progenitor of Hal, the rebel computer, in 2001: A Space Odyssey (1968).

Those links in Capra's The Turning Point (1982) are explained by a shift within physics from objects to relationships which requires a new "vision of reality." This vision, Capra says, is derived from Werner Heisenberg's view of subatomic physics as "a complicated tissue of events in which connections of different kinds alternate or overlap and combine and thereby determine the texture of the whole."

Hundreds of books, films, plays, poems, videotapes could be used to link art, literature, mathematics, music, science into what is now being called "whole language" approaches of English/Humanities. This linkage is not new; it has a foundation in the core curriculum and has certainly been part of the STS process for at least twenty-five years.

One final example for the Figure 7-3 Space/Time continuum: Lawrence Durrell, British novelist and author of what the press called a four-decker novel, The Alexandria Quartet (1957-1960), claimed that he used the "relativity theory" to design his books -- one dimension of space and three dimensions of time. Reality in that four-tiered novel was based on each protagonist's perception and narrated from those perceptions. All sorts of literary and scientific allusions abound in Durrell's Quartet until one is reminded of James Joyce's Ulysses (1922) and Finnegans Wake (1939), where layers of time and space are compressed into solopsistic meaning through mankind's unique identification in the universe, language. That language is simultaneously a demarcation for each discipline (e.g. the vocabulary of biology, physics, etc.) and yet the webbing across all disciplines, the unifying phenomenon our students need to discover for their survival in our global society.

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A NEW PARADIGM FROM AN OLD THEORY: COOPERATIVITY IN EVOLUTION EXAMINED AND TAUGHT THROUGH FRANK HERBERT'S NOVEL HELLSTROM'S HIVE

by

CARL FRANKEL AND JOSEPH MARCHESANI

The Darwinian Theory of evolution is the theoretical and philosophic core of modern biology. Two powerful ideas emerge from this theory: (1) All living things are related in a "family of life" and (2) Organisms are in constant competition for limited resources, and those with traits most successful for exploiting these resources survive to pass these traits on to future generations while the less successful die out.

The first idea was not original with Darwin and is not unique to his theory. Metaphorically, at least, the "family of life" message is compatible with most religious traditions, including the Judaeo-Christian, and lip service is paid to it, when appropriate, by almost everyone. Modern science has deepened and extended this idea. Ecology teaches us that the very matter we are made of springs from the earth, returns to it, and is recycled into other organisms in the family. Cosmology teaches us that the earth itself and the sun formed from a cloud of gas and dust left from the explosion of an earlier star. As Carl Sagan puts it: "We are all made of star stuff." These are grand, unifying notions, but they have had curiously little impact on the way we conduct our lives or on the kinds of political, economic, and technological orthodoxies we have fashioned.

The second idea is known as "natural selection," and was Darwin's conceptual breathrough - a mechanism for the process of evolution. The phrase "survival of the fittest," although not Darwin's, is a fair simplification of this idea, but it demands a proper definition of fitness. Most automatically associate fitness with strength, aggressiveness, and guile - the "law of the jungle." This "law" has been used to justify repressive social policies (social Darwinism), warfare, extreme laissez-faire capitalism, colonialism, even Marxist class struggle. All these doctrines center on competition, and their adherents turn to Darwin to show that such is the natural way of the world.

Thus, as a cultural paradigm the theory of evolution can point us in opposite directions - holistic togetherness with each other and nature, and aggressive competition against each other and nature. It is the second direction toward which the public mind has been drawn. We wish to show that this paradigm of unfettered competition is an erroneous notion based on misunderstanding of evolution theory.

First, most relationships in nature are not simply competitive. Different species compete to a certain extent for limited resources, but also rely on each other for food and maintenance of their environment. In the vast majority of relationships there is at least as much to be lost as gained by the elimination of "competitors," or even of predators and parasites. There are hundreds of well known examples of mutualistic symbiotic relationships between organisms specialized for different tasks and depending directly on each other for survival. The concept of winner-loser is thus spurious; success is more a matter of the health of the whole community, tied together in webs of dependence.

Second, and as a result of this, nature selects for stability far more often than change. Biologists have largely abandoned the picture of evolution as a slow, steady change resulting from periodic appearance of superior competitive traits. Most evolutionary change occurs in brief intense periods when climate change, volcanism, or collision of large bodies from space, and resulting extinctions, bring about massive disruption of ecosystems and a scramble for survival ensues. There is no indication that aggressive competitors are most likely to survive these cataclysms. Rather, small size, adaptability, and even pure luck are thought to be more critical factors. The role of cooperativity in producing major evolutionary change is not generally appreciated. It may be argued that among the most significant advances life has made on earth are those in which whole new levels of organization have evolved, with functional potentials physically impossible for the simpler forms that preceded them. There have been three or four such advances:

(1) Evolution of the first true living things - cells - from self assembly of interacting and mutually stabilizing organic chemicals.

(2) Evolution of modern (eukaryotic) cells from symbiotic association of two or three types of primitive (prokaryotic) cells.

(3) The evolution of large, i.e. multicellular organisms from unicellular ones.

To these three we may tentatively add a fourth: the evolution of social animals. The jury is still out in this case since it has occurred many times and to different extents in many evolutionary lines, including our own. The experiment achieves its fullest expression in the social insects. Biologist W.O. Wilson, an authority on these creatures, has stated that they are best understood if the colony, not the individual, is considered to be the organism.

In all these cases life achieved a major evolutionary advance by the merging of lower units of organization into vastly new higher ones. What was lost, for the lower orders, was independence. What was gained was participation in a more powerful, capable enterprise.

This view of evolution is relevant to STS studies because it provides a context for the evolution of human progress. Good technology, seen in this context, would be technology that is cooperative, providing benefits for our planet and its creatures that they may continue to benefit us. Aggressive technology that threatens our life-supporting network would be seen for what it is - bad technology. The same standard can be applied to good and bad political and social systems.

While we must not pretend to have discovered a morality in nature, the new paradigm of evolution allows us to pursue goals of mutual cooperativity and planetary consciousness - goals that are consistent with common sense and our highest moral values - and feel at the same time that we are participating in a natural process. A fuller understanding of evolution shows us that our capacity for bonding has higher ultimate survival value than our capacity for competing. This is a valuable lesson that deserves emphasis in schools where "Darwin" still conjures images of "nature red in tooth and claw."

It is easy to teach these concepts to a class of biology students with a solid background in evolution. Our STS students generally do not have this background, yet we consider human evolution very relevant to the course, particularly in our unit on biological engineering. Its focus is humanity's conscious intervention in its own evolution. As we do elsewhere in our course, we use science fiction to stimulate our students' imaginations on this issue. In this instance, we have found that an especially provocative work for our purposes is Frank Herbert's novel, Hellstrom's Hive.

Herbert builds the plot of his novel around two antithetical models of human society, one derived from eugenics and the other from social Darwinism. The hive that gives the novel its title results from a clandestine, long-term experiment in controlled human breeding. Over several centuries, the hive's population has become highly specialized, imitating the organization of social insects such as ants or termites. Most notable among these specializations are the researchers, whose abnormally large brains signify their high intelligence, and the breeders, whose skill in mating and producing offspring have been essential to the rapid advance of the hive's program.

Against this clandestine community, the novel pits a band of highly competitive American intelligence agents, who seek first to find out what the hive is about and then to destroy it. From the start, their efforts are compromised by pitiless internal competition as the agents conspire to advance their individual professional standings and to impair the standings of their fellow agents.

The novel is especially provocative for several reasons. Although the hive avoids genetic engineering, its use of human eugenics supplemented by surgical and bio-chemical manipulation seems just as problematic morally. Moreover, the conflict which drives the plot is disturbing at two levels. First, the human agents who are our nearest representatives in the text give us little to admire or respect. Second, even though Herbert depicts the hive with features that most readers would find distasteful, its suspect mode of organization succeeds handily, beating back the challenge from the story's human agents and promising to transform human society in its own image.

Because the novel offers these provocations in its themes and action, it enables us to challenge our students in important ways. First, it challenges their assumptions about the value of the individual and of the human species. It also confronts them with the implications of competition and cooperation at the level of socio-biology. And it forces them to evaluate a society radically different from their own: a human hive that prizes extreme specialization and intense interdependence.

To highlight these challenges in class, we focus on four features of Hellstrom's Hive.

(1) its unflattering depiction of ordinary humans as "wild Outsiders";
(2) those features of the hive that reject some common humanistic assumptions;
(3) the security that the hive provides despite those same features;
(4) the hive's success in surviving at the end of the story.

Let us elaborate on these points.

As noted, the representatives of humanity as we know it do not come across as an attractive lot in this story. For the most part, they are members in a secretive security agency having all the negative connotations of a domestic CIA. The governance of this agency is an abrasive hierarchy, authoritarian and insensitive. The agents themselves are self-centered and inexorably suspicious. The agency's operation discourages any sympathies they might develop for one another; all it can encourage is an edgy ambition. With back-stabbing as an essential element of policy, the agency's power is often misdirected and its effectiveness self-impaired. By the end of the story, two of its chief figures are dead: one an apparent suicide, the other a victim of sexual overindulgence. Its most effective agent is a captive of the hive, desperately urging the government to accede to the hive's demands.

With these representatives of humanity as the hive's opponents, Herbert can afford to let his readers see the hive's less humanistic features. First of all, the eugenics program that defines the hive produces a caste system in which hive members are bred for specialized functions: breeding, laboring, research, security, leadership. Obviously, such functions limit individual autonomy as the hive devalues any one member in favor of its identity as a whole. Even more disturbing is the hive's achievement in developing bio-chemical reinforcements for this caste system -- additives to the food, for example, that help to tranquilize the workers and strengthen their emotional bonds with other inhabitants of the hive. The most shocking feature of the hive, though, remains the "breeding stumps," the functioning female torsos that gestate embryos for the hive to accelerate its breeding program.

Even as Herbert confronts his readers with these disturbing features of the hive, he emphasizes the advantages that the hive confers in security and survival. With their self-awareness neutralized or diminished, most of the hive's inhabitants seem quite satisfied with their existence. Their satisfaction derives not from individual achievement or recognition but from the almost perfect fit that they experience with their community.

The only exception in the powerful coherence of this community exists in its principal figure, Dr. Hellstrom, who recognizes that the hive has not yet bred its perfect leader. Seeing himself as a transitional figure, Hellstrom longs for a leader who can be perfectly integrated into the hive while inspiring the innovation that will enable the hive to fulfill its potential. Despite Hellstrom's doubts, however, Herbert makes clear the evolutionary advantage that the hive has. And by expressing this advantage through the historical records of Hellstrom's predecessors, Herbert gives them the force of authority. These passages justify the hive with an objective support that shields its mode of being from our doubts or our objections.

Confirming this support, Herbert uses the plot itself to establish the hive's success by the end of the book. Although the "wild Outsiders" decipher what the hive is doing, their effort to destroy the hive fails. Through its highly specialized researchers, the hive develops a superior technology that can counter the more extensive weapons of its human attackers. Forcing the attackers to accept the hive's continuing existence, Hellstrom gains for his community the time it needs to complete its breeding program and develop the next phase of human evolution. Ultimately, he predicts, the "wild Outsiders" will be absorbed into the hive's own gene pool. By then, humanity as we know it will have been displaced by the descendants of the hive's cooperative community.

As you can imagine, most of our students resist Dr. Hellstrom's conclusion and reject the values that Herbert has associated with the hive. They prefer humanity as we know it and the continuing hegemony it implies. But we measure our success with Hellstrom's Hive by the degree to which the book disturbs them. In their disturbance lies their recognition of another paradigm for humanity, an intensely communal one. We want the course to provoke such recognition.

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Writing as a Bridge Between School Science and Society: A Theoretical Perspective

Science students, from elementary school to college, commonly hold two misconceptions: one is that scientists have little need for writing; the other, that science is a solitary pursuit carried out in isolation from society. Most of their teachers know the inaccuracy of such assumptions. They recognize, for example, the precise and vivid writing of Charles Darwin and Albert Einstein as essential ingredients of Darwin's and Einstein's scientific genius and as an important reason for the impact their ideas have had on humanity. They might point to the creative scientist's search for what Howard Gruber calls "images of wide scope," metaphors that have the power to shape and--just as important--communicate to others their searches for answers. Darwin's image of the branching tree of nature is a famous example. Nevertheless, classes at elementary, secondary, and undergraduate college levels often do little to refute the idea that science only minimally concerns human discourse. After all, students "do" science in the laboratory or in the field, not at the typewriter or word processor. Too often, science students write only to record isolated bits of data; their knowledge is assessed through short-answer, so-called "objective" tests. Matters of value, of ethics, tend to be relegated to the humanities, while the sciences are confined to matters of empiric truth. Finally, as members of this conference realize, science too often seems isolated from its social setting.

In these papers, Marion Tangum and I address the need for teaching science in ways that underscore, rather than mask, the rich involvement between science and society and that use writing as a bridge to the understanding of these rich connections. I take a theoretical perspective, exploring theories of knowledge, literacy, and rhetoric that underlie the practice of using writing to learn; Marion Tangum will describe how writing has been used as an integral part of a project funded by the National Science Foundation, to teach science to middle-school students; she will suggest ways that both science teachers and English teachers can engage students in writing to learn science.

I will begin by clarifying what writing to learn is *not*. Then to clarify what writing to learn *is*, I will define it as a way to promote active learning of course content in any discipline. Finally, I will explore what using writing to learn can teach all of us, students and teachers alike, about what it means to be literate and what constitutes both effective writing and effective learning.

Writing to Learn

When we suggest using writing to help students to learn biology, or any other discipline, we are not suggesting that teachers doom themselves to grading essays, research papers, or essay examinations, although we certainly see value for students in completing such projects and in receiving thoughtful responses to them. Nor do we mean that science teachers should mark students' errors in grammar and spelling and punctuation more than they already do, or laboriously edit for students the work they turn in, or teach the mechanics of composition. In short, we are not suggesting that teachers burden themselves with more grading or with more content to teach. Instead, we are offering another tool for teaching science, a tool that can be used to teach virtually any discipline.

Writing to learn is the use of writing, not to report or record learning for a teacher to evaluate, as students do on essay tests and research papers, but to bring about learning. The primary aim of such writing is the learning itself, not a written document.

The theoretical basis for writing to learn is the concept that active writing necessitates active thinking. By *active writing* I mean composing, as opposed to copying passages composed by someone else. The concept dates at least as far back as Descartes' argument that human knowledge does not result from experience itself but from the creation of discourse to organize, or make meaning of, experience. Meaning results, then, not simply from encounters with the world but from the use of language to order those encounters. Descartes' theory of the role of language in making meaning is echoed and developed in the work of later philosophers, among them Locke, Kant, Cassirer, and Langer (Knoblauch and Brannon 51-76).

To record this language in writing magnifies its power by making its meaning subject to re-examination, because it has become permanent--subject to comparison with experience and to verification. That one word must follow the other on the page; that the words stay on the page, in linear order, implying logical relationships and inviting scrutiny--these characteristics of written language lead writers to form new insights, to create verifiable knowledge. As language theorist Ann Berthoff explains, "It is the *discursive* character of language, its tendency to 'run along,' . . . which brings thought along with it. It is the discursive, generalizing, forming power of language that makes meanings from chaos" (70).

Writing specialist Toby Fulwiler emphasizes that to write is to be *actively* engaged in thinking and learning: ". . . [W]riting is the specific activity which most promotes independent thought. Both the decision to write and the process of writing are actions; one cannot be passive and at the same time generate words, sentences, and paragraphs--thoughts" (25).

If the idea of assigning such writing is to generate active learning, then--obviously--copying information from textbooks, chalkboard, or lectures is inadequate. In addition to the writing they do to take down information, students might write for these purposes:

- Connect and synthesize ideas
- Consolidate information
- Formulate definitions
- Analyze arguments
- Pose questions
- Establish a record of learning
- Investigate feelings
- Draw conclusions
- Communicate with an instructor about a class

Such writing might take various forms. It might consist of a journal for the course; a special course notebook that contains at least as much response and analysis as recorded information; short responses to reading assignments; five-minute writings done as a class activity at the beginning or end of a meeting, to focus thinking, to take a stand on an issue, to react to readings or other materials presented in class. Usually, however, such writing is short and unedited; it is often written primarily for the writer rather than for another audience; it is never corrected by a teacher and often is not even read by a teacher (Tchudi 20). Rhetoric and composition theorists have referred to such ungraded writing as "workaday writing" (Tchudi 20), as "writer-based" prose (Flower 19), and as "expressive writing" (Britton). Even though the goal of such writing is active learning and thinking about course content, improved class discussion also can result. Some students feel safer volunteering ideas they have put in writing, and--even better--the ideas arrived at through writing tend to be more carefully considered than immediate oral responses.

A Special Definition of Literacy

The rationale for using writing to learn science in this active way is consistent with a related understanding of what it means to be literate.

Many of us have followed over the last three years a debate among theorists over the problems of literacy in our nation's schools. I am thinking particularly of E. D. Hirsch's recent book, Cultural Literacy: What Every American Needs to Know, in which he calls for what he terms "Cultural Literacy"--an ability to recognize names, dates, slogans, organizations, and the like that are familiar to literate Americans. Writing to learn can correct two troubling notions in Hirsch's book.

One notion is that so brief a list of discrete items can, as Hirsch proposes, contain what *every* American needs to know. Detractors have been quick to point out the incompleteness of the list. (Among the acronyms for organizations, why leave out the ACLU, so crucial to reading news coverage of the last Presidential election? Why leave out the SCLC? Among the diseases listed, why omit alcoholism and leukemia, but include arteriosclerosis and sickle cell anemia?) Robert Scholes found 75 items, not on Hirsch's list, that a person would need to know to read the front page of one edition of the Washington Post (328). To be complete, such a list would have to read like a combination dictionary and desk encyclopedia--and, although the usefulness of such reference works has long been recognized, the idea of setting out today to know everything in an encyclopedia is startling. Clearly, if the list were complete, it would be too cumbersome to be useful. Nevertheless, shortening the list of items that "every American needs to know" presents problems I've already hinted at. Each of us will shorten the list according to our own lights, which are inescapably idiosyncratic: self-centered, ethnocentric, political. And few are willing to have their literacy measured by a list so edited by someone else.

But Hirsch's second notion about literacy troubles still more--the notion that literacy consists of the ability merely to recognize the items he judges essential. Surely full literacy lies in the ability not only to recognize references in texts, but to analyze them critically, to assess their arguments, their methods of investigation. Such power also includes the ability to relate new texts to already-familiar ones, to synthesize information, and to create texts of our own. All these abilities are what Paulo Freire, Ira Shor, and others term *active literacy*. The connection between these literacy debates and the practice of using writing to learn across the disciplines turns on the term *active*. The five-minute writings, the journal entries, the analytical note-taking--all involve students' thinking actively about the discipline, actively *using* information rather than passively recording it.

Writing for Audiences

My final point is that using writing to learn in the sciences can achieve for students a clear and usable understanding of what constitutes effective writing for audiences: effective writing gets done the work it sets out to, and it does so by reaching its intended audience. When students write for themselves as readers, they are able to judge confidently whether they have achieved their purposes: if their records of an experience clarify it for them, if their definitions of terms work for them, they needn't worry about another reader's judgment. However, students can confront a greater writing challenge, and also come to terms with the social nature of science, by writing for a variety of audiences, including off-campus readers, for definite purposes.

As students write about science for real audiences, they place science in a social setting, and, at the same time, they confront the true nature of rhetoric. Rhetorical theorist Kenneth Burke has written that rhetoric exists because of division between people, a division which is a fundamental fact of human existence because each of us has a separate, closed nervous system. We seek to remedy that separation, to achieve what Burke calls "consubstantiality," or the sharing of substance, with other human beings (62). Burke argues that the primary use of rhetoric is in this quest to close the division between ourselves and others (21-23).

The prospect of uniting ourselves with others is powerfully motivating; it explains why writing done for real readers can elicit committed responses from students. They can write definitions and explanations for less advanced students. They can write letters requesting information from government agencies, professional scientists, and politicians. They can write letters to decision-makers, expressing informed opinions based on the science they have learned. They can write professional scientists for answers to their questions. The need for precision, completeness, and control of usage and tone becomes self-evident when students write for readers who, unlike teachers making traditional academic writing assignments, do not already know their messages or their reasons for writing.

Marion Tangum will show you the results of some writing projects eighth-grade students completed last summer for real audiences. The result of all such projects is to learn science better and, at the same time, to emphasize the connections between science and society. As an oceanographer at Texas A&M University once said, "If it isn't published, it isn't science." Her statement suggests that science and language are inseparable. And it places both science and language where the action is: among people.

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A STUDY OF COMPUTER-WRITERS IN AN UNDERGRADUATE COMPOSITION CLASS

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A Study of Computer-Writers in an Undergraduate Composition Class

In a 1987 column, Ellen Goodman notes the inescapable fact that in spite of our efforts to objectify technology and its consequences, we are "stuck here in the high-tech, high-risk world with our own low-tech species. Like it or not, no mechanical system can ever be more perfect than the sum of its very human factors" (A23). While Goodman was referring to those mechanical systems which appear to control our very existence, substituting a less menacing mechanical system--one which supports word processing--I suggest that the same truth applies to our efforts to de-humanize our research into the quality of computer-generated prose.

What students write for undergraduate courses is increasingly being produced with the aid of a computer and some form of word-processing software. The apparent pedagogical question, "Does this new writing tool improve the product?" is being answered with varying degrees of certainty by researchers studying writers on all educational levels and in a variety of occupations. (See, for example, Bean; Bridwell, Sirc, and Brooke; Collier; Daiute; Gould; Halpern; Kiefer and Smith; and Sommers.) Most of these studies have focused on the apparent changes in the processes of these writers; others have compared on and off the computer products. In the scramble to answer questions about product and process, the differences among writers, in many instances, have been ignored or controlled. But we teach writers--those humans factors--whose experiences with word-processing must be taken into account.

This study developed out of my curiosity about what I felt was a heightened sense of urgency on the part of writing teachers and students to join the computer revolution. I wondered whether in our efforts to join the revolution, we had lost sight of the persons whom we would have participate in it. It was with this curiosity that I began an inquiry to seek understanding of the experiences of selected undergraduate students enrolled in a composition course as they made use of the computer to compose written documents.

The inquiry was guided by the following question: What is the experience of using the computer to compose written documents like for undergraduates in a writing course? In the context of this conference, another way to ask that question is "What does it mean to be technologically literate in a writing class? To inquire into these experiences, I drew upon the ethnographic techniques of interviewing, participant-observation, and document analysis of solicited compositions in which students were asked to reflect on their continuing computer-writing experiences.

To place the study in context, I first provide a brief description of the writers, the course, and the setting. An interpretation of their shared experiences follows. Finally, I offer reflections on some additional ways in which writers might be taken into account in the practice of teaching composing with the aid of computers.

Description of Context

The writers

The group studied was comprised of full-time college students enrolled in a required upper-level composition course. The schedule of classes indicated that this section of the course "involved computer-assisted instruction." Most of those who enrolled did so either because they had had previous computer experience and felt that such a section would support that experience or because they had had little previous exposure and saw this course as an opportunity to acquire it. Others indicated that they took the course because it was the only section available at the time of registration. Ten of these students were identified for in-depth observation and interviews. Two of the ten were theatre majors; two were journalism majors; two were government and politics majors; two were business and management majors; one, a psychology major; and one, a radio, television, and film major. Six were male. Six were interviewed twice; the other four were interviewed once, for a total of sixteen interview sessions.

The course

In this course, students write a series of argumentative essays developed around topics of pre-professional interest. As each argument contains salient points from the earlier ones, the students generally find it particularly convenient to have copies of previous papers stored on disk to be called up for editing, revising, and expanding.

The setting

While there are several computer labs located throughout the campus, this lab is unique in that it is dedicated solely to the production of written documents to fulfill the requirements of a composition course. It contains seven terminals connected to a Sperry Unix Midi Computer, which stores files on a Winchester hard disk. Students are assigned log-in names which allow them to access their files and to make use of other Unix capabilities, such as the spelling checker, the editor, the formatter, the dictionary, and Writer's Workbench. In addition, the lab contains one microcomputer. Students use the writing lab outside of class, coming when their schedules allow.

Interpreted Experiences

The experiences of these writers are presented here as they unfolded through inquiries into their attitudes towards computers, their perceptions of writing and of themselves as writers, and their perceptions of their experiences in using the computer for writing.

Attitudes towards computers

One prominent attitude was that of computers as anthropomorphic. Our discussions of the computer often led to comments suggesting the assignment of human-like qualities to the machine. Here is how one conversant described his high school computer course:

> The teacher was good at making you understand exactly what the computer can do, so you really do become like one person working--if that's possible for a machine and a person to become one.

He later added,

> I really feel like the computer is a person instead of just a machine. If it makes a mistake, I always think, "No it can't be. It's gotta be my fault because supposedly this thing doesn't make mistakes.

Another student's comments suggest her need to reassert herself as person over the machine. I had asked her in what sense could any computer experience be beneficial in adjusting to another one. She replied that it could teach her "that that's a dumb machine and I'm a person."

Another prevailing attitude was what I call reverence for computers and computer scientists. Those who revered computers believed that they are smarter than people and that people who program computers are smarter than those who do not. Consequently, while the computer was perceived as human in many respects, it was perceived as a much smarter human. Harold, a student who offered abundant data, said:

> When you type something in and it tells you that you made a mistake, all of a sudden, the computer is smarter than you are, so you tend to feel inferior about that.

When asked about her previous experiences with computers, another replied, "I have bad luck with them. They're too smart for me."

This reverence for computers and computer scientists was often in response to what students considered to be "authentic" computing, which did not include word processing. Several of the conversants expressed the view that word processing was not really computing. Computing meant programming in mysterious languages where, as one student put it, "you can't type what you really mean."

When one writer was asked about the impact of computers on society, she responded as follows:

> Whenever I think of computers I think of them as word-processors, and I think of computers that other people use-- the people that are scientific and mathematical, they use computers for a totally different reason. What they're doing seems really hard to me.

And because using the computer "really seemed hard" for many, their determination to master it grew. The will to master has been described by Burch as a manifestation of the hubris of "Western subjectivism" (5). It is a pride which assumes that everything should be at our disposal, controlled and mastered, or, to use Heidegger's term, "enframed." Those students who could not participate in this enframing experienced frustration. Frustration was another very common response. It is not surprising that those in awe of the computer and its programmers would also experience frustration with what they perceive as their inability to master the machine. The word most frequently used to describe previous experiences with computers was"frustrating." One student saw our course as "the first step towards getting over my fear. I guess frustration is a better word. Because any other kind of experience I've had with computers was not productive." She felt that high school students should be required to take a computer class basically to learn "not to be intimidated by the machine."

When asked on a questionnaire "Describe your feelings about computers," another answered, "I don't like them" and used the word frustrating throughout the description of his previous experiences with computers. Still another student responded to the same question "frustrating and unreliable" and described her previous computing experiences as "not very pleasant." And another conversant said, "My feeling was at one time fear. Now it is mild apprehension."

A fourth prevailing response was that computer skills were professionally enhancing. For many, the desire to acquire computer experience was motivated by the belief that it would enhance their careers, that some knowledge of computers would increase their chances of finding a good job, and that such knowledge would keep them up-to-date. Roszak called this belief "one of the issues on which the ethics of the teaching profession require candor." He contends that "what they [students] are learning in a few computer lab experiences will not make them one iota more employable" (63).

Still the opinion prevails. Perhaps this student's statement epitomizes this attitude best:

> I just think that everything is gonna eventually end up that way and most everything now is computerized in some form, so in order for me to get a job, I thought it would look nice if I had computer experience. It might help me get a job over somebody else.

Views of Writing and Self as Writer

During the course of the conversations, students made statements which gave indication of the ways in which they viewed writing and themselves as writers. It was felt that an understanding of these perceptions would shed light on the nature of their experiences in writing with the computer.

Their attitudes ranged from feelings of total inadequacy to extreme confidence.I'm the worst writer. I have this block when it comes to writing," said one student.

A returning student, who hadn't written an academic paper in six years, talked about his anxiety: "What was it like? It was a scare. I didn't know whether I'd even be able to compose a letter." When asked to estimate her writing abilities, another said,

> I think too much; if I were to write as I speak, I think I could be a lot better, but I try to make it sound intelligent, and then I get really confused as though it's not me speaking. When I write, most of the time it's someone trying to be me.

Another experienced trouble getting started, and one particularly adamant student put it this way:

> I do as little writing as I possibly can to survive, to get by in life. I never liked writing. It was always a chore for me.

But later during the same conversation, the respondent suggests that the computer might change this attitude: "I think I might like to write with all that stuff at my fingertips to help me."

These reactions caused me to raise the following questions, recorded in my journal, about what I was hearing:

> What possibilities for success are available to students who come to the computer writing lab with anxiety both about using the computer and about writing? How do both activities call upon persons to perform in ways which are different from the requirements of other activities?

The Writer at the Computer

Having considered these persons' responses to computing and to writing separately, I now turn to a discussion of some of the issues which dominated our conversations about the experience of integrating the two activities. The effects of typing skills; the importance of time, mood and environment; the computer as stimulus; and the computer as reviser and editor were dominant ones.

The Effects of Typing Skill

Students were questioned about their typing ability as it affected their composing processes. Those who knew the keyboard and typed well thought it was important to know how to type before trying to use the computer; those who had limited typing skills wished they had more, but still felt that the computer offered them an advantage.

Harold, who didn't type at all, thought that using the computer might actually help him learn to type:

> It's already helping me. I know where the letters are. I'm using more than just my index finger. And it is faster, but no, I still have to look.

Another admitted that he was a very poor typist who spent four hours typing his first two-page assignment on a conventional typewriter. But he did not see his lack of typing ability as a hindrance to composing at the computer; in fact, he believed the computer facilitated his typing process.

One student and I discussed the fact that when someone else types the final draft, that person will often make additional changes in the text. He felt that the computer changed this situation for him: "But see, with this [the computer], I can do it."

Writing in a Computer Lab

Time, environment, and mood emerged as significant peripheral concepts associated with the act of writing in a computer lab. When asked what it was like to write in the lab, most students responded to the difficulty of getting and remaining there rather than to any displeasure with the environment itself.

> It's just hard because you have to go to wherever the computer is. And it's hard because you sort of write whenever you get into the mood. Sometimes you're not in the mood when the lab is open.

When asked if she felt there would be any advantage to having a computer writing lab if most students owned personal computers, one person said, "To set the mood maybe."

This last comment caused me to question the role of the lab in helping to "set the mood." On the one hand, having to come to the lab at designated times was constraining if the students were not in the mood to write, but on the other, the lab may actually have helped to create or invoke that mood.

Mood, time, and environment were especially important for Bob, who arranged to use the computer lab one weekend morning and stayed there for five hours. I asked him what it was like to work in the lab for that length of time: "It helps me more. If I get into a creative mood, I have to stay in a creative mood; otherwise, I lose all my thoughts."

Harold came to the lab almost every Wednesday afternoon whether he had work to do or not. When I asked about his frequent visits, he replied simply, "I want to come. I like this place."

Harold's remark led me to question the extent to which the lab itself might have offered a place where it was safe for students to be writers, to take risks.

One student's difficulty with writing in the computer lab led me to inquire more specifically into the kinds of social interaction that may have taken place there. I asked one conversant whether composing in the lab had given her opportunities to confer with others about the writing assignments:

> With regards to interacting with others, most of the time, we are all playing beat the clock Tuesday or Thursday morning, so we don't talk much. A few times, I joked around with Bob or Frank, but other than that, there's been little interaction for me with other people.

Computer as Reviser

That using the computer facilitates revision has been well documented. The shared experiences of these writers confirm this finding. It seems that using the computer may have made them better writers by facilitating the process of making the changes they knew they should make; it reduced the temptation to "let it slide."

Computer as Stimulus

Less well documented is the extent to which writing at the computer actually stimulates the initial composing process itself. Not only did the computer make it easier for some to revise text, it also promoted its creation. Bill explained it this way:

> The computer's sitting there. It's staring at you. It's saying talk to me. There's something about working with the computer that kinda sparks your imagination a little bit. You can see what you're doing in front of you. You feel like you're accomplishing something. You can revise it just like that. You can really make it good.

Later in our conversation I described how the purchase of a new pen often inspired me to grade a stack of essays. Bill remarked,

> That's very similar to the idea of sitting in front of the computer and having it pull things out of you to a certain extent because you enjoy writing more.

When comparing writing with pen and paper or with a typewriter to using the computer, Bill added:

> [But] The computer says, "Just type and it's okay." I can go back. [I think] the computer is the closest thing to having yourself plugged into a system that would just flow with your thoughts. Because if you can type well, you can type as fast as you can think.

Time as a Unifying Theme

I questioned the extent to which these students' orientation to clock-mandated time inhibited their ability to become not only effective writers, but truly educated persons, as well. There is a certain irony here in their struggles with time. The irony is that, while technology developed, to a large extent, out of the human desire to save time, this same technology also seems to restrict our ability to take full advantage of this "free time." Our lives are so completely enframed in technology, that it is difficult for us to recognize other ways of being in the world. As Burch says, "If we are technological beings essentially, then our leisure time free from the exercise of instrumental power is time for nothing" (12). What would a different understanding of time, time as kairos, allow these writers to experience?

Summary

Finally, I offer some possibilities which these findings suggest for further inquiry into the creation of a meaningful learning environment composed of writers, teachers, and computers.

Possibilities for Further Inquiry

1. What changes might occur in writers' attitudes towards technology over a year's rather than a semester's time? Would observations of writers over this extended period show a reduction in the anxiety and frustration many of them experience? Are there writers who would simply never make the transition to using the computer for writing?
2. To what extent should computer use for writing be required initially to allow students to experience it? How important is such a skill to future employment?
3 How might the role of the writing teacher change in a setting which makes use of computers?To what extent might computers free the teacher to devote more attention to the development of ideas and to engage in dialogue with students?
4. How might the combining of a computer writing lab and a writing center provide a more comprehensive writing environment for students? How might such an environment provide better assistance to writers on all levels and at various stages of writing? How might this setting promote writing as a

cross-disciplinary activity? How might this combination provide a continuing role for a computer writing lab, as more students acquire personal computers for home or dormitory use?

5. How might a computer lab help to promote writing on a college campus by providing a place where students gather solely for the purpose of exchanging ideas and expressing themselves through the written word in an informal and collegial setting? How might such a setting promote peer evaluation? How might it support the idea of writing as a social act, so that the computer actually promotes person to person exchange.
6. How can the tool of writing, the computer, best support the tool of learning, writing?

It is to be hoped that this inquiry into the experiences of these "human factors" has offered some insight into what it means to teach people, caught up in or trying to catch up with a new writing technology.

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Writing To Learn: An NSF Summer Experience

As June Hankins has underscored in her theoretical perspective "Writing as a Bridge Between High School Science and Society," integrating the writing process into the science process actively engages students in the dialogue of science: an energetic, ongoing exchange which is the essence of practicing science--and of learning itself.

That kind of activity was the approach that we at Southwest Texas State University took this past summer in a four-week residential institute, sponsored by the National Science Foundation, for eighth grade students from rural schools in Texas. Our primary goal was to expand the science knowledge of high-potential students from some of our least privileged schools, by offering 24 of such students a "hands-on" science program. Another goal was to increase these students' awareness of the connections between science and society. Interestingly, we accomplished both of these goals by focusing on a third: to enhance these students' ability to *communicate*.

We didn't begin by listing "What Not To Do"; we talked about grammatical options--and some of what we considered to be rules--only as they occurred within the context of actual writing to real people, when we had individual examples of grammar constructions that, for one reason or another, did not "work" to bring the writer to the reader.

And we didn't end by grading a mound of papers; as a matter of fact, we never graded a thing. Yet every one of those 13-year-olds, over the course of the four-week experience, was motivated to achieve college-level writing: writing that was both clear and convincing to the human beings who read it. That was something they didn't think they could do. They were able to do so because, we believe, the projects we engaged them in enabled them to see--and respond to--the integral connections between science and society which writing helps to illuminate.

Writing To Learn: The Catalytic Social Situation

Of course, those connections are what scientists must deal with. As chemistry professor Alton Banks observed, scientists do not practice science within the confines of a laboratory: to practice it, they must communicate it. We therefore designed all of our students' writing projects to focus on the real rules of writing established by real social settings.

Journal

The initial writing project for our students was a form of the ungraded--entirely unedited--"writer-based" writing which June Hankins points to as a key to "active learning" and, therefore, the foundation for making logical connections among individual units of study. From the first day of our Institute through its last, each participant commented on the day's science experiences in his or her individual journal.

These journals were not for the purpose of providing students with a private diary of their summer experiences; rather, they were to provide a forum for daily writing to learn. So they wrote every day about what happened--what they saw as especially significant that particular day. "What happened" varied from one student to another; their journals were thus unique and individual, for they wrote what was of particular interest or concern to them. When they had trouble writing their experience in detail, we found out why: they had not understood the experience they were engaged in. This gave us a chance to fill in gaps: to have students compare journals and so learn from each other; to suggest to professors what points from yesterday's experiences they might re-present in today's experiences; and to carry discussions of puzzling questions beyond the walls of the classroom, into the lunchroom and dorm. We subsequently noticed that in writing about "what happened" the next day, students began by making connections to their experiences the day before. We found, as the following "before" and "after" passages illustrate, that *after* students realized that they would use their journals--speak from them and about them in social situations--they developed a real reason for writing logically, and so learning.

But they couldn't do that immediately; here is one student's initial effort at recording what was significant about the Institute's first day:

> 7/12/88:
> Today I woke up. This morning we got dress and went to eat at the cafeteria. Went to our first class and took a test. We all did not understand it that well. Then we went to our second class it was interesting. Then Physics came, that was the best we had so much fun.

Here is that same student's comments about a moon-photographing session which occurred just one week later:

> 7/19/88:
> Tonight [the moon] should be waxing crescent. I'm very excited but scared the picture will not turn out right or be too bright or dark. Or even too long in the negatives. Finally it is my turn. I'm shaking a little and I go up to the camera. Now I'm getting calm. Then Dr. Olson told me "Anytime." So I squeezed the bulb and then something happened! I think a dial slipped because my first picture was too bright. So Dr. Olson asked me to do it again. So then I was saying to myself, "Oh it is all right, I'll be able to do it again and it was not my fault!" I took the picture again at about 10:30 p.m. Then I went into room 101 and developed my negative, and I took a perfect picture. We get to keep the pictures.

You can enable your students to achieve this same type of writing--writing that is charged with personal connections and, so, draws readers into it--by having them keep a journal in science, or in English *about* science, every day. To make it effective, you don't even have to read it: you will engage your students in it and enable them to learn from it by integrating that journal into the social setting of the science lab or the English classroom.

Letters

The second real project that our students worked on was letters: not to be graded; rather, to be mailed--to the student's own science teacher back home. And for a real reason: to explain something they did in physics which they particularly enjoyed and to do it in such detail that their audiences would respond, "I'm there." Here is what one student started and finished on the first day of this project:

> 7/12/88:
> Dear Mrs. Markle,
> My assignment is to write you. We had fun in Physics today. We have done interesting experiments. The food is OK but I miss home. I'd write more but I gotta go now.

We assured Zack that he did *not* "gotta go." Here is an excerpt from the letter that we finally mailed:

> 7/19/88:
> Dear Mrs. Markle,
> We have been doing some really interesting experiments in physics class which is this weeks subject. Polarization was one of the most interesting topics. We did one experiment with some polarized lenses to decide if the light off of various objects was polarized. We had three polarized lenses marked to show which way the light was allowed to go through. You observed several objects to see which way the most light came through. There was one especially interesting part of the experiment in which there was a reflection of the tree in a polarized window. If you turned the polarized lens one way you could see the tree, or any other reflection in the window; but if you turned it the other you couldn't.

Zack obviously didn't think about polarization in the lab itself; but he *did* consider it seriously when he had to write about it and found that he could not. Paradoxically, the failure of his initial effort enabled him to envision the questions that he had to answer--which he did by looking again at his class notes, asking his friends, and going back to his instructors for detailed explanation--in order to write effectively.

In a following week's project, we asked students to write to us, writing instructors whom they knew well, to explain and defend their opinion of a question raised in their philosophy class: whether cosmetic companies' practice of using rabbits to test for allergic reactions to their products is ethical. We had not been present at the philosophy discussion and had no idea of the position that the philosopher took on the issue; obviously, then, we weren't "testing" their competence at taking accurate class notes. Instead, we were asking them to show us something that we knew nothing about: their *opinion* of the arguments they had heard. What interested us was that they had no real idea of how they felt about this issue--until they had to write it for a real audience. Here are a couple of opposing views:

> From an ethical point of view I feel that it is the greatest good for the greatest number of *people*. I feel morally wrong about what we are doing to the rabbits, but I would feel worse if I ever saw my mother with puffed-up lips.

That student's vivid imagery convinced me; but one of his colleagues disagreed:

> Utilitarianism breaks all moral dicisions down into an equation. The equation says: act always so as to produce the greatest good for the greatest number. For this you must rate the pleasure that every person or animal involved in the Revlon experiments experiences, such as the consumers, scientists, president of the company, sadist assistants, etc. Then you must rate the pain that any of the same or different people or animals feel. Here, I think that a mistake was made. You can't actually rate pain with a number. I would like it if you could, but you really can't. Pain is an abstract thing depending on the environment of a life-form. Saturn's atmosphere might be painful to us, but pleasant to a Saturnian. So improving the air on Saturn for the humans would give an entire race a new planet (us) and kill or disable an entire race. You couldn't say the pain was more intense for the Saturnians or that the pleasure was more intense for us. Both races would argue that they were experiencing greater pain/pleasure. You can't say how much pain/pleasure is being experienced in terms of a number unless you are experiencing it.

I think that letter reveals remarkable insight for a thirteen-year-old. He didn't simply churn it out, of course; he wrote and rewrote his letter for all of a solid week--not for a grade but for something that became more important: the desire to know *himself* what he thought and to convince his audience that his thinking was valid.

Lab Report

Similarly, we engaged students in real social settings when they worked on lab reports. They did not write to prove that they did something right; rather, we encouraged them to report anything and everything that went wrong. They submitted these reports to chemistry professors, colleagues of their own professor who certainly knew what the experiment should have entailed but who had not led the experiment themselves and so did not know what actually happened in each individual case. Students worked on this project extensively in class, writing and revising in teams of two; I acted not as grader but as coach.

Here is an example of the specific detail that you might enable your students to develop if you were to guide them through such a project:

> The first thing that we did was to make sure all equipment was satisfactory. We did this by rinsing all the equipment with distilled water. After all equipment was checked, we filled the buret with the copper sulfate solution that was diluted to one mole per mL. The buret was filled to 50 mL. We then took the volumetric flask and filled it with 25 mL of the CuSo4 solution which was then combined with 75 mL of water. After the water was added to the solution, we put a secure cap over the flask and shook it up until the two substances were mixed together. We then poured a sample of the mixture into a cuvette which we then took to test the absorbance.

Instead, of course, you might get something more like this:

> We put the cap on and shook the flask, and copper sulfate splattered out and got all over Zack's shoes.

That team obviously had skewed results; but writing everything down enabled them to see clearly why--and to see the significance of integrity in assessing scientific results. As Nobel physicist Richard Feynmann admonished graduating scientists in his commencement address at Caltech (1974), science depends on "a principle of scientific thought that corresponds to a kind of utter honesty--a kind of leaning over backwards" to provide audiences with a complete picture: "You should report everything that you might make the [experiment] invalid--not only what you think is right about it."

Next, we engaged our students in a lab report with a different focus and for a different audience--their own cell biology professor who had assisted each of them in preparing a specimen to photograph using a scanning electron microscope. Since he had, in essence, carried out the procedure himself, he did not want them to report what they did; he already knew that. What he wanted to know, instead, was what each student perceived in the results--what it seemed like to them. Here is what one student saw in hers:

> The result I got from using the SEM was a 3x5 photograph of a crayfish's gill, although if I hadn't known what it was, I couldn't have told you that. It was magnified 157 times, and was only a very small part of the gill.
>
> To the left of the photo, there is an undefined area which looks similar to a mossy substance. Going through this area at a right diagonal tilt is a white stick with little teeth (like on a comb).
>
> In the center of the picture is a 3x2 inch dark gray area with strands that look a lot like magnified hairs or roots coming off of a potato or a carrot. In the center of the dark area, behind these 'hairs', is a bright spot that looks like a miniature ghost but is probably a bacterium or a diatom. Looking at it reminds me of looking at a ghost in prison because the 'hairs' look like bars.

Having to write about--and so think about--what that crayfish gill was to *her* made science come alive for this student. As June Hankins assured us it would, making connections through writing analogies brought this student's experience to life for her. Writing connected the science to the unique human being--and she saw that as fun.

Synthesis

Science knowledge, of course, is not a scattershot of isolated, discrete experiences; obviously, it is making connections among them and extending them to the broad social setting in which we live. If you ask your student to write to you as curious human being--not as grader--you will enable them to perceive at least some connections that would never occur to them unless you asked. You may find that they make connections that you had not thought of yourself. Again, asking them to compete with each other in this project--or to collaborate with each other--will open their minds to new connections. That is what we did for our final week's writing project. Our students wrote the Program Director to tell him what they particularly enjoyed during the final week's study of Ecology--and to give him *their* ideas of how all of the other weeks' studies related to that one.

Here is one thirteen-year-old's connections:

> The one activity that I enjoyed the most this week was seining the Blanco River for various types of fish and other organisms. This was especially interesting to me because of the many different types of fish and other organisms that were in the river that I never even dreamed of existing. I am also fascinated by the mechanical build of a fish in relations to that fish's environment, because I never really understood why some fish have rounded tails and some have tails shaped like V's. I also never understood why certain fish have certain types of epidermal covering.
>
> This past week's study of the fish relates to our first week's study of physics. In this first week we studied the principle of waves. We learned the characteristics of light, sound, and physical waves. In Ecology we learned that many fish send off waves in the water to detect what is around them. They also detect waves emitted by larger predator fish and animals. Other fish also detect these things with light waves simply by seeing them.
>
> This program has made me understand more than the physical part of the sciences. I have learned that science is in out hearts and minds as much, if not more, than in the laboratory. We must learn that sometimes a personal sacrifice must be made by us, and that we must sometimes choose between being a scientist and being a person. An example is the problem presented about the scientists at UT working on the Star Wars program: some had to decide whether to be a professional and take the money or to follow their personal morals and refuse the offer. There is not always a definite answer to an ethical question in the science world.

This still-rough result--but one that is highly charged with thought--is the kind of writing and learning that virtually any thirteen-year-old is capable of, if we teachers turn into coaches and allow all students' learning experiences to be governed by the contingencies of the real social settings in which both science and writing occur.

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What We Know About Effective Intervention Programs for Minority Students in Elementary and Middle Schools

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What We Know About Effective Intervention Programs for Minority Students in Elementary and Middle Schools

This paper will describe intervention programs in general, give a rationale for the growing focus of intervention efforts on elementary and middle school students, present an overview of the extent of intervention programs for this age group in the U.S. (drawing on a study funded by the Ford Foundation), describe characteristics of effective intervention programs, and discuss how effective approaches can be applied in the classroom.

What Are Intervention Programs?

History. Intervention programs in science and mathematics to increase the participation of females and minorities in math- and science-related careers are a recent phenomenon. They emerged from the civil rights movements of the 'sixties and 'seventies and had their origin in the realization that women and minorities--Blacks, Hispanics and Native Americans--were severely underrepresented math and science careers. At first the programs were mainly local initiatives based on locally identified needs. Resources, too, were derived locally. Once these programs had been in existence for some years, however, they began to attract national attention and, as a result, federal and foundation funding (Malcom, Aldrich, Hall, Boulware, & Stern, 1984).

Characteristics of intervention programs. Since intervention programs arose out of the recognition that formal education had failed to address the problem of minority and female underrepresentation in math and science, it is logical that the programs should utilize approaches somewhat different from those of the traditional education system. As a result, intervention programs have a number of characteristics that set them apart from the formal education system:

- They operate separately from the school system (although they may be in-school programs offered during the school day).
- They often involve a disadvantaged group or groups, such as minorities, women, and the handicapped, and aim at counteracting some educational inequity suffered by one or more of these groups.
- They use innovative instructional techniques, materials, and curricula.
- They often focus on addressing one problem area--such as math and science--rather than addressing the whole range of educational problems.
- They engage in activities that address many aspects of the problem, not just those that are achievement focused.
- They employ multiple strategies to obtain their objectives.

- They are sensitive to the needs of the groups they are intended to serve and develop their intervention approaches around those needs.

What Do Intervention Programs Do?

Most intervention programs address one or more of the four barriers to minority participation in math and science. These barriers have been identified by research and include the following:

- Negative attitudes towards math and science;
- Lack of information regarding math and science careers;
- Low performance levels in these subjects;
- Failure to participate in higher level math and science courses in high school.

These barriers affect different underrepresented groups at different points along the math/science pipeline. For example, elementary and middle school intervention programs for minority students would place an equal stress on intervention activities to influence attitudes and to increase performance whereas those for females would focus on improving their attitudes and information about math/science careers with less of an emphasis on improving performance. The rationale for these different approaches lies in an examination of the math/science pipeline and in the description of the progression of different groups through that pipeline. A look at the pipeline as well as at the points of greatest leakage for minority students suggests that intervention at the elementary and middle school levels is a must if the scientific talent pool is to be increased.

Why Intervention in Elementary and Middle School?

Although the first intervention programs targeted students in high school or college, there has been a growing awareness that the factors impeding minority access to math and science careers are present before high school. In order to participate in a math- or science-related career a student must first develop an interest in math or science, acquire the necessary skills to do well in the courses, take a sufficient number of courses in high school, and persist in a math or science major through college. A look at the education pipeline through which students pass on their way to math and science careers reveals that the talent pool seems to reach its maximum size before high school, although migration into the pool still occurs through grade 12 (Berryman, 1983) and perhaps beyond (Lee, 1987). Attempts to increase the pool, therefore, should focus on the pre-high school years, while post-high school intervention efforts should concentrate on keeping minority and female students in the math/science pipeline.

What events occur at the middle school phase of the pipeline that make it a crucial point for intervention and what are the most effective intervention approaches at this stage? First of all, the middle school years (defined in this paper as grades four through eight) determine whether or not a student will participate in the academic track, a prerequisite for access to advanced math and science courses (which in turn predicts higher performance levels in math and science). Second, these years have been pinpointed as the period during which both female and minority interest in math and science wanes. Third, recent research shows that minorities as early as the second grade perform below grade level in mathematics in greater numbers than do Asian and White students and that the gap widens with each successive year (Gross, 1988).

Research on the factors affecting minority attrition from the math/science pipeline at this stage reveals that minority students have positive attitudes toward mathematics and science during the elementary school years (Kahle & Lakes, 1983; Maccoby & Jacklin, 1974; Matthews, 1984; NAEP, 1983; Wilder, Mackie & Cooper, 1985). Some research has indicated that the positive attitudes of minority students suffer a decline as they reach the middle school years (Disinger & Mayer, 1974; Hill & Lynch, 1983; Kahle & Lakes, 1983; Schreiber, 1984). The exact age at which this occurs is not known although there is a consensus that grades 6 through 8 are critical in the development of attitudes towards mathematics and science (Fennema, 1976; James & Smith, 1985). For minorities, however, it seems that attitudes are unrelated to performance whereas for females, attitudes seem to affect their achievement in math and science. Both Black and Hispanic students, despite their lower levels in mathematics and science, have attitudes as positive as those of White students (Gross, 1988; Jacobowitz, 1983; Walker & Rakow, 1985).

Research on factors affecting minority participation in math and science at the middle school level suggests, therefore, that intervention for minority students should from the first work on both attitudes (with an emphasis on career awareness and exposure to science) and development of skills.

Intervention Programs for Elementary and Middle School Students: A Status Report

A recent study of math and science intervention programs for minority elementary and middle school students described the status and scope of these programs in the U.S. (Clewell, Thorpe & Anderson, 1987). Tables 1, 2, 3, 4, and 5 give characteristics of the 163 programs identified by the study.

Table 1: TARGET POPULATION

Target	N (Programs)	Percent
Minorities	54	33
Females	21	13
Minorities & Females	88	54

Table 2: SUBJECT AREA FOCUS

Subject	N (Programs)	Percent
Math	29	18
Science	17	11
Computer Science	4	3
Math/Science	39	24
Science/Computer Science	5	3
Math/Sci/Comp. Science	64	40

Table 3: POPULATION SERVED

Population	N (Programs)	Percent
Females	109	67
Minorities	143	88
Blacks	135	83
Mexican Americans	67	41
Puerto Ricans	67	41
Other Hispanics	46	28
Native Americans	57	35
Asian Americans	34	21
Whites	95	58

Table 4: PROGRAM ACTIVITIES

Activity	N (Programs)	Percent
Role Models	88	54
Direct Instruction	108	66
Counseling	96	59
Field Trips/Tours	77	47
Guest Speakers	88	54
Hands-on Experiences	137	84
Special Projects	54	33
Contests/Science Fairs	46	28
Study Groups/Clubs	38	23
Tutoring	36	22
Test Preparation	29	18
Job Shadowing	11	7

Table 5: GEOGRAPHIC DISTRIBUTION OF PROGRAMS

WEST		CENTRAL		NORTHEAST		SOUTHEAST	
Arizona	3	Illinois	9	Connecticut	4	Alabama	1
California	21	Indiana	5	Delaware	1	Arkansas	1
Colorado	6	Iowa	3	District of Columbia	9	Florida	2
Hawaii	3	Kansas	1			Georgia	12
Idaho	1	Michigan	7	Maryland	4	Louisiana	1
Montana	1	Minnesota	4	Massachusetts	3	North Carolina	3
New Mexico	3	Nebraska	1	New Jersey	5	Virginia	7
Oklahoma	4	Ohio	7	New York	12	West Virginia	1
Oregon	1	Wisconsin	3	Pennsylvania	6		
Texas	6			Rhode Island	1	Puerto Rico	1

Characteristics of Effective Intervention Programs

Part two of our Ford Foundation project involved choosing ten effective intervention programs and studying them in depth, using the case study method which involved site visits, interviews with project directors, instructors, participants and parents. Our final report to Ford looked across programs to determine what they had in common. These we categorized as "characteristics of effective programs." These characteristics were classified as part of "Program Goals," "Program Design," "Program Content," "Participant-Related Outcomes," and "Program Context." Because I have a limited amount of time, I will comment on "Program Content" because this is the area I felt would be of most interest to this audience.

In terms of program content, we found the following to be characteristics of successful programs:

- Effective programs offer a mix of services and activities.
- Included in the mix of activities offered by effective programs are academically-oriented activities.
- Effective programs emphasize enrichment rather than remediation.
- Effective programs are innovative and creative in designing approaches to address the problem of underrepresentation.
- Successful programs utilize multiple approaches and strategies.
- Effective programs use inquiry/discovery approaches in teaching as well as activity-based, hands-on activities.

- They incorporate some of the characteristics of cooperative goal structures such as lack of competitiveness, a high degree of interaction among students, and group responsibility for goal achievement.

- They teach problem-solving and/or higher order thinking skills.

- Strategies and techniques used by effective programs are appropriate for their target populations.

- Successful programs work with classes of mixed ability students.

- Effective programs require a high level of student involvement and activity; they are student centered.

- Effective programs have training for teachers and other staff to introduce them to program objectives as well as program strategies and approaches.

- Instructors in effective programs have the following characteristics: They have high expectations of students, give them feedback and encouragement, have a thorough knowledge of subject matter, and a knowledge of the populations they will be teaching. They also have the ability to accommodate instruction to students' cognitive and learning styles.

- Successful programs have a high level of parental involvement and strive to attract, involve, and work with parents of participants.

Approaches and strategies. Because these are very general, I would like to focus on actual approaches and strategies used by the programs. These are organized according to the barriers that the programs address: Attitudes/Career Choice and Achievement/Performance.

Attitudes/career choice. Intervention strategies that focus on encouraging positive attitudes towards math and science and on increasing participants' awareness of opportunities for careers in these fields utilize a number of approaches: role models, career awareness activities, exposure of students to out-of-school science and math activities, and provision of a supportive environment within the confines of the program, in school and at home. Particularly creative approaches were the development of video materials featuring peer role models and involvement of students in a regional science fair. Other innovative approaches include the use of drama and writing to introduce students to role models in science and mathematics as well as to role play their involvement in these subjects.

Achievement/performance. Instructional techniques common to all programs were the use of inquiry/discovery approaches in teaching as well as activity-based, hands-on activities or the use of manipulatives. There was very little use of the traditional lecture method and where there was, this was combined with the discovery/inquiry approach. Most programs incorporated some of the characteristics of cooperative goal structures such as lack of competitiveness, a high degree of interaction among students, and group responsibility for goal achievement. All the programs taught problem-solving under one guise or another.

The majority of the programs offered tutoring and different tutoring approaches included peer tutoring, cross tutoring and tutoring by adults.

All programs offered training for instructors. The training introduced staff to program goals and approaches and encouraged behaviors in instructors that have been found to improve instruction, such as having high expectations of students, giving them feedback and encouragement, having thorough knowledge of subject matter, and a knowledge of the populations they were teaching as well as the ability to accommodate instruction to students' cognitive styles and locus of control orientation.

A family/home environment that is supportive of an involvement in math/science can be achieved by focusing intervention activities on parents. Involving parents in the program can take many different forms: One program involves parents in the policy making process by including them on the advisory board. Several programs offer classes for parents and their children together, or parents alone. Some programs ask parents to sign a contract that they will review their children's homework and engage in other activities that will help their children's achievement in math and science. Other programs involve parents through parent workshops, monthly meeting for parents, parent volunteer activities. One program even has a parent coordinator to encourage parents to become involved with the program.

The role of innovation. A characteristic of effective programs is that they are innovative in some way, either in program design, unique approaches to teaching, curricula and/or materials. These programs are different from traditional programs and have responded in an innovative way to the problem. In fact, one of the reasons they are effective is that they are willing to be creative and to take risks. That is, in the absence of generally accepted strategies and designs for effective intervention they have been resourceful and unconventional in devising solutions to the problem of low minority and female participation in math and science.

How Can These Approaches be Transferred to the Classroom?

This is a problem that many practitioners and researchers are grappling with at this stage. In order for an intervention to be successful, it must ultimately be capable of being used in a formal educational setting. Many successful programs make an effort to disseminate and institutionalize their practices. These efforts take the form of careful documentation of practices, the production and publication of curricula, teaching materials, teacher/staff training packages, career awareness materials, and manuals containing lesson plans and a complete description of project activities.

Some programs also hold training workshops for school personnel. And some programs are designed from the beginning with institutionalization in mind. There needs to be more research on effective methods of transferring the lessons learned by intervention programs to the regular classroom setting. Only when effective strategies are institutionalized will intervention programs be truly successful.

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WASHINGTON MESA AND BEYOND

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WASHINGTON MESA

A Program that Encourages Minority Students to Stay on the College-prep Track

Washington State **MESA** (Mathematics, Engineering, Science Achievement) is designed to increase the numbers of underrepresented minorities in mathematics, engineering, and science related professions, fields which currently attract a particularly small percentage of Blacks, Hispanics, and Native Americans. The program currently provides academic support services to over 1600 middle and high school students across the state, seminars and workshops for teachers and advisors, and college admission workshops for students and their parents. The academic support services include enriched middle school math and science classes, an elective high school science class designed to introduce students to current engineering topics, after school and Saturday programs, summer enrichment programs at all levels, career exploration, role models, field trips, and tutoring. The teacher workshops are the vehicle through which teachers stay current in their field, receive information on careers in science and engineering, and communicate with other teachers across the state who are interested in encouraging minority students in the sciences. The parent-student sessions focus on college admission requirements, including SAT preparation, financial aid, scholarship applications, and registration procedures. The MESA middle school summer enrichment program provides in-depth science laboratories for seventh and eighth graders; the tenth grade MESA summer enrichment program is centered around structures; the MITE (Minority Introduction to Engineering) gives eleventh graders laboratory experience in each engineering discipline at the University of Washington; and BRIDGE, a residency program for entering freshmen, gives the students a math and physics refresher course while orienting them to life on campus.

Washington MESA serves a diverse population. The Centers in Seattle and Tacoma serve urban areas in which 85% of the MESA students are Black. The MESA Center in the Yakima Valley/Tri-Cities area serves a population in which 76% of the students are Hispanic Americans. A MESA Center in Spokane is being developed, and the primary target population will be Native American students on reservations surrounding Spokane.

MESA works. Washington MESA began in 1982. Between 1986 and 1988, MESA graduated 388 students from the in-school program, 324 (84%) of which are currently enrolled in college and 159 (41%) are majoring in math, engineering, or science.

NATIONAL SHORTFALL OF TECHNICAL PERSONNEL

The U.S. economic and technological base is being threatened by current shortages of scientific and engineering personnel and by forecasted decreases in university enrollments, particularly in the sciences. The National Action Council for Minorities in Engineering (NACME) projects that if the same proportion of college graduates earn engineering degrees as in 1983, there would be 16,000 fewer engineers in the year 2000 (1).

The projected decreases in the number of engineers and scientists is compounded by the underrepresentation of minorities and women choosing these fields. There are two factors to consider. First, black, Hispanic, and Native American enrollment in higher education has continued to decline since 1976, even though the respective high school completion rates have significantly increased (2). The number of blacks graduating from high school increased 8.1% between 1976 and 1985; however, the percentage of black students entering college dropped more than seven percent, from 34 percent to 26 percent. The actual number of Hispanics graduating from high school continues to grow, as does the number of Hispanics entering college; however, the picture is not the same when one examines percentages. While the percentage of Hispanics graduating from high school in 1985 compared to 1976 has increased by 7.3%, the percentage entering college has actually decreased by 8.9%. Therefore, in actuality, higher education is losing increasing numbers of qualified Hispanics. The percent of eligible Hispanics who enter college has declined from 36% in 1976 to 27% in 1985.

Table 1

NATIONAL COLLEGE ENROLLMENT BY ETHNICITY
Percent of High School Graduates Enrolled in College

	Black	Hispanic	White
1971-72	29.2%	25.8%	33.5%
1976-77	33.5%	35.8%	33.0%
1981-82	28.0%	29.8%	32.5%
1985-86	26.1%	26.9%	34.4%

U.S. Department of Commerce, Bureau of the Census, Current Population Reports, in Minorities In Higher Education.

Secondly, the percent of minority and women college students who choose engineering is also decreasing. The Engineering Manpower Commission (3) indicates that black, Hispanic and Native

Americans made up 23.0% of the total college enrollment in 1985 but accounted for only 9.8% of the full-time engineering students. The story is the same for women. The number of women entering engineering peaked in 1985 (4). In 1986, both the number and proportion of women entering engineering dropped as anticipated. The trend is reflected in the University of Washington enrollment data from 1980 -1987.

Table 2

UNIVERSITY OF WASHINGTON FEMALE ENROLLMENT
1980 - 1987

	% of Total	% of Engineering
1980-81	48	18
1981-82	48	18
1982-83	49	19
1983-84	49	20
1984-85	51	18
1985-86	48	17
1986-87	48	17

University of Washington's Office of the Registrar.

The most recent assessments of the status of mathematics and science education in the United States (5,6) indicates that our students are not prepared for a science-related course of studies at the college level or for the various demands of an ever-increasing technological society and workforce. Even though the mathematical performance of our nation's students has improved somewhat over the past eight years, most of the progress has occurred in the domain of lower-order skills. Nearly half of our nation's 11th graders (17-year-olds) do not have mathematical skills that go beyond basic computation with whole numbers, and less than 10% of them can use these mathematical skills to solve multi-step problems. And the data are even more pronounced for underrepresented minorities and females. A joint commission of the National Academy of Sciences and the National Academy of Engineering (7) called for a restructuring of the way mathematics is taught in the United States.

The National Action Council for Minorities in Engineering reports (8) the teacher to be the critical factor in the intellectual development of students. Changing the way mathematics and science are taught, and thereby increasing the numbers of students entering the sciences, a task which rests on the shoulders of mathematics and science teachers, is one of the major goals of MESA.

MESA - MATHEMATICS, ENGINEERING, SCIENCE ACHIEVEMENT

MESA's mission is to assist our state and nation in achieving an educated citizenry that is globally competitive and individually competent in mathematics, engineering, and science, with full participation of blacks, Hispanics, Native Americans, and women. MESA accomplishes this through a partnership of higher education, school districts, business and industry, and community organizations. The partnership is dedicated to providing these underrepresented students with an education process that increases their interest, effective participation, and contribution to mathematics, science, and engineering.

The University of Washington's College of Engineering has been working since 1976 to develop a comprehensive support program for minority students from junior high through the university level. Today, there are three components in place: MESA is an out-reach program for middle and high school students, the Minority Engineering Program (MEP) provides support for minority undergraduates, and the Women in Engineering (WIE) Program is being developed to offer support to undergraduate women.

In 1976, the University of Washington's College of Engineering administered a program which provided speakers for junior and high school mathematics and sciences classes. In 1982-83, with matching funds from the Hewlett Foundation, MESA began as a program for 88 minority students in three Seattle schools. In 1983-84, MESA served 135 students in five Seattle schools, providing an in-school elective science class, minority scientist role models, field trips, and tutoring. In 1983-84, a National Science Foundation grant provided seed money for the MESA high school program to expand to two other centers and the establishment of the Washington MESA State Office. The Tacoma Center is sponsored by Pacific Lutheran University, and the Yakima Valley/Tri-Cities Center, housed in Richland, is sponsored by Washington State University. The Washington MESA State Office, located at the University of Washington, coordinates the MESA activities within the state. The three MESA Centers - Seattle, Tacoma, and Yakima Valley/Tri-Cities - as well as the Washington MESA State Office are now totally supported by the MESA state budget, which is a line item in the University of Washington operating budget. The current MESA state budget provides funds to develop a MESA Center in Spokane, a project which is well under way. In addition to these four state supported MESA Centers, Honeywell Marine Systems Division and the Honeywell Foundation support a MESA program in Mukilteo. A National Science Foundation grant in 1987 provided seed money to expand the MESA program into the middle schools in all existing Centers. In 1988-89, MESA will provide services to over 1600 minority and women students in eight districts which comprise 71% of the minority population in Washington state.

The MESA State Office, housed in the Universitiy of Washington's College of Engineering, is administered by the Washington MESA State Director, who reports to the MESA State Board of Directors.

The MESA State Board, which is appointed by and reports to the Provost at the University of Washington, is made up of representatives from universities, school districts, and statewide industry. MESA is currently supported by school district, university, industrial, state and federal funds.

Each local center is administered by a director with an advisory board composed of representatives from local industry, their school district, their sponsoring university, professional science and engineering organizations, and community groups.

Table 3

WASHINGTON MESA ADMINISTRATORS BY GENDER AND ETHNICITY
1988 - 1989

	Black	Hispanic	Native American	White	TOTAL
Female	4	0	0	2	6
Male	1	0	0	0	1
TOTAL	5	0	0	2	7

MESA State Office, January, 1989.

MESA's goals are:

- Encourage students from the target minority groups to acquire the academic skills they need to succeed in mathematics, engineering, and the sciences.
- Promote career awareness and involve students in projects and activities oriented to mathematics, engineering, and science careers early enough to allow students to complete the prerequisite courses to enter college.
- Encourage schools, universities, industry, engineering societies, and others to offer volunteer time and fiscal resources.
- Strive to make MESA activities an integral part of educational programming in the public schools.

Washington MESA is a program designed to prepare black, Hispanic, Native American, and women students to study mathematics, engineering, or science at the college level. MESA focuses on students who have the potential to succeed in a college preparatory curriculum, but who are not taking the necessary mathematics and science courses. There are four components basic to the MESA Program: 1) student support services, 2) teacher support services, 3) parent involvement, and 4) industrical partnerships.

During 1988-89, MESA will provide support services to over 1600 middle and high school students across the state of Washington. The MESA middle school program consists of enriched in-school mathematics and science classes, after school and Saturday mathematics and science activities, career exploration, including exposure to minority role models from local industries, field trips to industries, science museums, and universities, and enriched summer programs held on university campuses.

Table 4

WASHINGTON MESA STUDENTS BY GENDER AND ETHNICITY
1987 - 1988

	Black	Hispanic	Native American	Other	TOTAL
Female	558	200	60	78	896
Male	467	175	53	0	695
TOTAL	1025	375	113	78	1591

MESA Center Director Reports, June, 1988.

MESA high school students must have expressed an interest in mathematics and science related careers and are required to enroll in a college preparatory curriculum consisting of four years each of high school mathematics, science, and English. All students participate in the MESA tenth grade science class, either as part of their in-school program or as an after school or Saturday class. The MESA tenth grade science class consists of seven engineering projects designed to show students how their math and science knowledge is used in applied engineering problem solving. For each project, professional engineers and scientists give presentations to the class, and field trips are made to industrial or univeristy sites that are engaged in related work. In addition to the science class, the MESA program at the high school level includes tutoring and group study support, incentive awards for high academic achievement, SAT workshops, financial aid and college admissions workshops, and enriched summer programs held on university campuses.

Washington MESA offers three summer programs, one for middle school students, one for students who have just completed the tenth grade, and one for students who have just completed the eleventh grade. The middle schoolers spend five weeks on a university campus exploring five science topics in depth. Each unit includes hands-on science activities incorporating the computer as a tool to be used when necessary: to collect on-line data and graph it, if necessary; to alleviate tedious calculations; to do sophisticated analysis; to carry out simulations; or to facilitate design. A Department of Education grant provided funds to develop the curriculum units, and the work currently under way includes: an unit on pendulums focusing on developing scientific reasoning; investigations of simple and compound machines; the study of pumps with a focus on the heart; experiments and activities with electricity; and the study of water quality control. Each unit will include a presentation from a professional scientist or engineer working in the field and a visit to an industrial site that is doing related work.

Table 5

WASHINGTON MESA STUDENT SERVICES

- Student Support Services
  - Middle School Program
    - Enriched mathematics class
    - Enriched science class
    - Field trips
    - Career exploration
    - Summer science program
    - Family Math and Science
  - High School Program
    - Introduction to Engineering class
    - Field trips
    - Career exploration
    - Incentive award for academic achievement
    - Tutors and study groups
    - Summer programs

MESA State Office, January, 1989.

The MESA Summer Program for students who have just completed the tenth grade is a five week course of studies focused on physics, mathematics, and computer applications using structures as the central theme. The course is held on a university campus and is taught by university science and engineering faculty. The course includes presentations by professional scientists and engineers in industry as well as from various departments within the university. The career explorations also include visits to industrial sites that are involved in work with a structural component. The course includes the study of the many bridges which abound in the Puget Sound area, and as a final project the students, working as engineering teams, compete in a bridge building contest.

Minority Introduction to Engineering (MITE), a two week residential program held on the University of Washington campus, is for any minority student who has completed the eleventh grade. The program comprises an introduction to the studies offered within the College of Engineering. For each of the nine fields of study within engineering, a morning lecture and demonstration schedule is followed by an afternoon laboratory experience. In addition to the course work, the students are exposed to the amenities of univeristy life, in particular, the library system, the museums, the intramural sports program, the numerous campus restaurants, and the dormitories.

The National Action Council for Minorities in Engineering sees the teacher as a main force in the education of our nation's children. "Second only to the family as a critical element in the intellectual development of students is the quality of teaching - the attitudes, skills, and behaviors teachers bring to the classroom and their application of teaching methods and instructional instruments" (8, page 26). The MESA teacher is the underpinning of the entire MESA program. MESA teachers become involved in MESA usually in one of three ways. Some teachers learn of MESA from their colleagues or their students and want to get involved; some teachers are recommended by their colleagues or their administrators; and some teachers are recommended by the students. MESA teachers are perceived by their students and their colleagues as teachers who care about their students and who believe their students can and will meet with success. These teachers include well-prepared "master" teachers as well as less well-prepared mathematics and science teachers who have been recruited from other disciplines.

The Washington MESA approach for achieving institutionalization has been "bottom up". MESA teachers play a key role in influencing administration to provide the required building support for the program.

MESA makes a concerted effort to recruit teachers of color, but just as the number of underrepresented minorities who go into the sciences has an impact on science and engineering, it also impacts mathematics and science education. However, of the 41 current Washington MESA teachers, 15 have ethnic backgrounds that have been historically underrepresented in the sciences and 17 are women.

Table 6

WASHINGTON MESA TEACHERS BY GENDER AND ETHNICITY
1988 -1989

	Asian	Black	Hispanic	Native American	White	TOTAL
Female	1	6	1	0	9	17
Male	0	5	3	0	16	24
TOTAL	1	11	4	0	25	41

MESA State Office, January, 1989.

Current findings suggest there are factors in addition to compentency of subject matter that are crucial to students' success. Results of mathematics and science intervention programs with minority and female students (8,9) show successful secondary mathematics and science teachers: are knowledgeable of future as well as current career options in mathematics, engineering, and the sciences; effectively make use of community resources; and have high expectations for their students. Research in mathematics and science education indicates (5,6) successful teachers: involve students in hands-on activities and projects on a regular basis; consistently set mathematics and science problems in real-world contexts; have students regularly work in small groups; and regularly provide projects that encourage scientific reasoning. Washington MESA provides a seminar series through which MESA teachers can refine these skills that are so crucial to students' success and through which they can keep can abreast of innovative approaches to bring into the classroom.

A Parent Council consisting of parent representatives from each school in which there is a MESA class has been established at each MESA Center. The Council works with the Center director in an advisory role and is responsible for keeping parents informed of all MESA activities, those for students as well as those for parents.

MESA provides workshops for students and parents. In September, MESA invites students and their parents to an orientation workshop. The Center director, MESA teachers, local professional scientists and engineers, concerned community representatives, and current MESA students and parents give an overview of the MESA program from the various perspectives. Throughout the year, MESA holds workshops on the various steps in the college application process, including workshops on financial aid, available scholarships, and entrance tests and requirements. In the Spring, MESA holds a banquet in honor of the graduating seniors, to which all MESA students and parents are invited. It is at this banquet that outstanding MESA students are recognized by various professional and community organizations.

MESA middle school teachers offer Family Math and Family Science (10) workshops to students and their parents. In the three sessions, offered in the evenings, the students and parents work as family teams to problem solve a series of activities that are similar to those done in the MESA classroom. These workshops reinforce the parents' support of MESA, aid the parents in learning about innovative approaches in the classrooms, and prove useful in helping them help their children with homework.

At each MESA Center, the local advisory board is made up of representatives from school districts, universities, professional science and engineering societies, community organizations and local industry. Industry not only plays a vital role on the advisory boards, but it also provides financial support to MESA. In addition, industry provides role models for the classroom and takes an active role in curriculum development. The basis of the MESA curriculum is the partnership between education and industry, a partnership in which the professional scientist or engineer works with the school teacher to develop classroom activities that place mathematics and science in a real-world context.

Each MESA center sponsors special conferences to encourage women and minorities to seriously consider engineering or science careers. These conferences, held on university campuses, industrial sites, or science museums, include sessions for students and sessions for parents.

MESA WORKS

MESA works. MESA began in Seattle in 1982, graduating seniors for the first time in 1986. Between 1986 and 1988, MESA graduated 388 students from the in-school program, of which 324 (84%) are currently enrolled in college, and 159 (41%) are majoring in mathematics, engineering, or science.

Table 7

WASHINGTON MESA GRADUATES
1986 - 1988

	Seattle (in-school)	Tacoma (Sat. prog.)	Yakima Valley Tri-Cities (in-school)
Graduates	292	307	96
Enrolled in College	242(83%)	173(56%)	82(85%)
Math-Based Major	112(38%)	50(16%)	47(49%)

MESA State Report, September, 1988.

BEYOND MESA

The University of Washington's College of Engineering Minority Engineering Program (MEP) is designed to increase the number of underrepresented minorities receiving bachelor's, master's or doctorate degrees in engineering. MEP, initiated in 1981 with 109 underrepresented minority students, now provides academic and non-academic support services to over 300 Black, Hispanic or Native American pre-engineering and engineering students. (At the Univeristy of Washington, engineers declare a major commencing with the junior year, therefore, MEP works with pre-engineering students, freshmen and sophomores who have indicated an interest in engineering.) These services include adjunct classes for all mathematics, physics, and engineering courses offered at the pre-departmental level, individualized instruction and tutoring, financial aid, peer support and study groups, assistance with matriculation, academic counseling, career exploration and career planning, and summer orientation programs.

MEP is administered by a director housed in the College of Engineering. The Industrial Advisory Board is made up of representatives from local industry. MEP is funded by industrial, university, and federal funds.

MEP offers the Bridge Program, a two-week residential program held on the University of Washington campus, to all potential MEP students. Bridge, as the name implies, provides a transition between high school and university life. The students study mathematics, science, and learning skills while becoming familiar with the University campus and forming friendships with other MEP students.

The MEP Study Center, the hub of MEP, offers academic counseling, assistance with registration procedures and financial aid applications, peer tutoring and group study, and a place to meet others with similar interests.

The success of MEP is reflected not only by the significant increase of underrepresented minorities in pre-engineering and engineering, but also by the increased number of degrees earned. Between 1971 - 1980, the decade before MEP was in place, an average of 5 underrepresented minorities per year earned bachelor's degrees in engineering. MEP was instituted in 1981; 1985 saw the first MEP graduates. In the biennium 1985 - 1987, an average of 17 underrepresented minorities per year earned bachelor's degrees.

The Minority Internship Program offers an opportunity for students to gain engineering work experience while attending the University. Students learn more about engineering while improving their financial situations. The success of these internships in industry is reflected in the statistics. Since its inception, the number of MEP students on internships in the business and government sectors has climbed dramatically from 2 in 1981 to 52 in 1986.

The University of Washington is presently developing the Women in Engineering Program (WIE), modeled after the successful program at Purdue University. The goals of WIE are to increase the number of women choosing engineering as a course of study, to provide support services to alleviate the high rate of drop-out by female engineering students, and to encourage greater numbers of women to pursue graduate degrees in engineering.

MEP works. In 1981, the first year MEP was in operation, there were 24 junior and senior minority engineering students at the University of Washington. The numbers have steadily increased every year, and in 1988, there were 82 minority students in engineering at the junior or senior level. In 1981, 12 MEP students earned bachelor degrees, and 2 earned master degrees. The numbers have increased each year, and in 1988, 31 MEP students earned bachelor degrees and 6 master degrees were awarded.

Table 8

MINORITY ENGINEERING PROGRAM DEGREES EARNED
1987 -1988

	Bachelor	Master	TOTAL
Black	11	5	16
Hispanic	14	0	14
Native American	6	1	7
TOTAL	31	6	37

Minority Engineering Program, July, 1988.

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STS Science Education For Minority Students A View Through The Prism of Values and Intellectual Development

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Introduction

During the past decade, the goals of science education for grades K - 12 have been reformulated. New directions have been set with principle attention given to preparing all students to use science and technology to enhance the quality of their life, to exercise responsible citizenship skills in a technological society, and to prepare those so inclined to have access to science related majors at the college level.[1] A stimulus for reform has been the series of reports since A Nation at Risk which reveal the failure to graduate students who are scientifically literate and prepared to sustain a competitive economy in a technological world. While stimulus has come from economic analysis, the consequent reform movement addresses issues of importance to those interested in educational opportunity for minority students; issues such as failure to flourish where success depends upon availability of role models, adherence to specific value systems, and availability of courses which are relevant to future careers. With a focus on Personal Needs and Social Responsibility, STS Science Education accommodates students of diverse cultural backgrounds and interests. This paper discusses some aspects of STS Science Education which provide enhanced opportunity for minority group students, the merits of implementing STS Science Education during the middle school years, and mechanisms of assessing significant outcomes.

Minority Needs

During the past decade, the percent of Black and Hispanic college age students has increased, but their relative participation in higher education has decreased. For Blacks, participation in college peaked in the mid 1970's, and total numbers attending college decreased during the 1980's. In college science and technology, the decrease has been even greater, thus aggravating the under - representation of Blacks and Hispanics in those fields.[1] Some factors contributing to this include: a) Socioeconomic Status; b) Attitudes and Aspirations; c) Stereotyping and Role Models; and d) Cultural Values.[2] Those factors are interconnected in complex ways in the school. Academic tracking may foster continuance of socioeconomic status from generation to generation,[3] attitudes and aspirations within minority cultures are sometimes perceived as limiting,[4] and conflicting recommendations for new course offerings sometimes produce confusion.[5] STS Science Education offers a means to address those problems.

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[1] Harms, N. & Yager, R. (1981).

STS Science Education

STS Science Education is characterized by attentiveness to the interconnectedness of Science - Technology - Society. It is grounded in the goals articulated by Project Synthesis, focusing on Personal Needs of students, developing competency to address the Needs of Society, and Academic Preparation. The middle school is a particularly good setting to address those goals. Students in grades 6 - 9 are rapidly forming lasting self concepts and attitudes, and are developing fundamental social reasoning skills.[6] With appropriate instructional techniques, middle school teachers have opportunity to enhance student development of positive attitudes towards science, a sense of control over the use of science and technology for improving the quality of life, and assumption of responsibility in social affairs.

STS Science Education, through its focus on Personal and Social Needs, leads teachers and students to increased awareness of values of diverse cultural groups. Ethnocentric and androcentric values embedded in traditional science are more readily seen, and the complexity of providing rigorous and relevant science education becomes more apparent. The issue of accommodating minority ethnic groups in rigorous science courses is no longer an issue of how to enable students to flourish in a system with inherent values which are at odds with ones cultural heritage, but, as shown by Feminist studies, an issue of constructing science programs without the limitations of traditional androcentric and ethnocentric values.[1] One means of moving towards that end is to construct and use multifaceted assessment measures which relate culturally unique value systems to STS Science Education goals. The measures described below[2] allow for those considerations. The measures are selected and/or constructed from the works of Piaget, Kohlberg, Gilligan, and Bruner. Combined, they provide a framework for understanding STS Science Education for minorities.

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[1] While 13% of the college population is black, they comprise only 9.5% of undergraduates and 4.8% of graduate students. Only 4.8% of Law students, 5.8% of medical students, and 2.6% Of practicing engineers are Black. Mingle, J. (1987).

[2] Ascher, C. (1985).

[3] Hotchkiss, L. (1984).

[4] Ascher, op. cit., Young H. (1983).

[5] Recommendations that Blacks learn cultural values of Whites (Young, op. cit.; Hayes, F. 1981) may diminish attentiveness to recommendations that science education be reformulated to eradicate arbitrary ethnocentric and androcentric values (Fee, E.; Rose, H. 1986). Recommendations that instruction be directed towards Field Dependent Learning Style (Jones, D. 1986) conflicts with evidence that instruction towards such learning style is ineffective (Glaser, R. 1972). Both problems demonstrate the complexity of enabling minority group members to prosper in the dominant culture while retaining their identity.

[6] On Attitudes, see Atwater, M. (1988) and James, R. & Smith, S. (1985). On Social Reasoning, see Gilligan, C. (1977) and Kohlberg, L. (1969).

Assessing STS Science Education Outcomes: New Measures

A variety of excellent tools for evaluation of middle school STS Science Education are available. William McComas and Robert Yager have developed The Iowa Assessment Package For Evaluation In The Five Domains of Science Education[3]; a comprehensive STS Science Education assessment program with instruments for evaluation in the domains of Knowledge and Understanding, Exploring and Discovering, Imagining and Creativity, Feeling and Valuing, and Using and Applying. At the University of Georgia, the GALT (Group Assessment of Logical Thinking) test and the MIPT (Middle Grades Integrated Process Skills Test) have been developed[4]; and surveys of related school attitudes, feelings, and values have been conducted and reported.[5] The above domains provide a broad view of science education and enhance opportunity to gear instruction to individual needs.

The objective of the work described here is to develop measures which complement those above and provide for enhanced understanding of the role of cultural values in the development of logical thought, scientific problem solving, and responsible decision making on social issues. Two tests are being developed. One test assesses development of simple and complex mental imagery, science problem solving and reasoning processes. Another test assesses stage of development of moral reasoning on issues of social justice, and social care and responsibility. Both tests are based on developmental norms established by Piaget, Kohlberg, Gilligan, and Bruner. Results of performance on those tests are useful for evaluation of the effectiveness of programs in meeting STS Science Education goals in the domains of Social Needs and Academic Achievement. In the domain of Personal Needs these tests assist in distinguishing normative developmental values from qualitative personal values. This provides a basis for understanding how personal values invigorate, obstruct, or compliment logical intellectual operations and decision making on societal issues.

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[1] Bleier, R. (1986). Gilligan, C. (1986).

[2] One instrument (Piaget-Bruner Microcomputer Test) has been field tested, with results reported in the accompanying paper "Attitudes, Judgement, and Mental Imagery". Development of the second instrument is in progress.

[3] McComas, W. & Yager, R. (1988).

[4] Cronin, L. & Padilla, M. (1986). Roadrangka, V. & Yeany, R. & Padilla, M. (1983).

[5] Atwater, M. (1988).

The first test is micro - computer based. The microcomputer permits interactive testing of cognitive abilities, and allows for assessment in a technological environment (using the microcomputer) emulating the modern work place. The cognitive processes assessed are common across cultures, prerequisite for expression of normative values of moral reasoning, and necessary for responsible decision making in a technological society.

The second test assesses development of moral reasoning and decision making. It incorporates dimensions identified by Feminist Studies as complements of the traditional Kohlberg approach. It provides for greater inclusiveness of diverse value systems and avoids the problems of reiterating traditional ethnocentric and androcentric values of science.

Piaget (1973) and Bruner (1986) provide keys to understanding the connections between cultural values, broad social goals, and scientific literacy. Each theorist distinguishes between personal values and "developmental" values (described by Kohlberg and by Gilligan). The latter are products of logical operations, and depend upon stages of cognitive development for existence. The former are often shared by members of common cultural heritage, and are used in selecting one path of action from among multiple paths available. Both types play essential roles in STS. Normative values are the foundation of broad based social ethics and the common denominator of a viable pluralistic society.[1] Qualitative personal values are the foundation of enriched personal lives and the source of motivation for engaging cognitive processing.

Common Basis of Assessment

Piaget has identified common characteristics of logic and mathematical reasoning, understanding of causality, the development of normative values, and the role of qualitative values in reasoning processes. Logic and mathematical reasoning evolve through stages that are evident across cultural groups.[1] Understanding of causality in physical phenomena is gradually constructed by interfacing of logic with regular physical phenomena in which actions of the individual play a role. The construction process further develops structures of logic and understanding of cause effect relations.[2] Although limited developmental differences occur as a function of differential experiences, the larger developmental sequence is consistent across diverse groups.

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[1] Parker, F. (1986).

Values which are normative (rules, laws, justice, social responsibility) are the product of adequate knowledge and structured logic. Qualitative values, on the other hand, are the product of culturally transmitted personal preferences; they form content which may selectively energize the operation of intellectual structures.[3] The development of normative values and moral reasoning is uniform across cultures to the extent that they express the structures of intellectual operations.

Each of the above is targeted for enhancement in STS Science Education; in Personal Needs, Societal Issues, or Academic Achievement goals. Using Piaget's concepts, the Personal, Societal, and Academic STS goals are understood in a common theoretical context. The two instruments discussed here use that context.

Instrument #1:

This instrument assesses development of simple and complex mental imagery, mathematical reasoning, scientific problem solving. Cognitive processes involved include ability to control variables, generate hypotheses, devise problem solving strategies, utilize mental imagery in solving problems, and proportional reasoning. Scores obtained from test performance are interval measures giving direct information on specific cognitive abilities. For those so inclined, scores may be interpreted in terms of stages of cognitive development. The abilities measured with this instrument are prerequisites for mature understanding of Science - Technology - Society issues, and are common to cognitive development across cultures.

Four of the nine problems were selected from Mental Imagery in The Child (Piaget, 1973). They assess Simple and Complex Mental Imagery, and are indicative of level of understanding of certain concepts within a given stage of development. Previous research indicates that these tasks discriminate between the perceptual and analytic components of Field Independence,[1] and that analytic imagery is a significant component of scientific and mathematical reasoning. Gender related differences in these Piagetian measures have not been found. Research indicates that Blacks often exhibit Field Dependent learning style, which may be a source of underachievement in science. The Piagetian measures provide insight into the analytic skills essential to scientific and mathematical reasoning, as well as information on level of development of structures of thought.

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[1] Inhelder, B. "Forward" in Modgil, S. & Modgil, C. Edt. (1979).

[2] Piaget, J. (1977).

[3] Piaget, J. (1973).

Two additional problems were selected from Epistemology and Psychology of Functions (Piaget, 1977), and evaluate processes used by subjects in proportional reasoning. Developmental performance on these problems depends upon the progression from qualitative to quantitative understanding of simple spatial components of physical systems (a spring with suspended weights; distance traversed by wheels of different size). Performance on these tasks is indicative of level of cognitive development of processes which are fundamental to analytic scientific reasoning. Perceptual and imagery components of performance on these problems are monitored in problems one through four. In previous research, performance on these tasks was found to account for a significant portion of the analytic component of Field Independence, and correlate significantly with achievement in science at the middle school, high school, and college levels.[2]

The eighth problem is based upon the work of Bruner. Four objects (large and small triangle, large and small square) are arranged as sixteen pairs. One pair is selected by the computer as the "correct answer". The subject must guess which of the 16 pairs is the selected pair. With each guess, limited feedback is given and a visible record of guesses maintained. Subjects are given eleven chances to find the correct pair. Five trials are given, during which ability to formulate effective search strategies is assessed. Bruner[3] suggests that subjects may construct concepts by discovering the conjunctive rule linking definitive attributes of simple objects, and that strategies of varying effectiveness are employed by subjects of different developmental level. Among the strategies are conservative focusing, focus gambling, successive scanning, and simultaneous scanning. Each strategy is distinguished by the attentiveness to and use of specific hypotheses, generated autonomously by the subject, designed to reveal the rule. Performance on this problem is indicative of level of development of basic science process skills required for controlling variables, hypothesis generation, and problem solving.

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[1] Doody, W. (1981).

[2] Doody (1981); Doody and Feldstein (1982).

[3] Bruner, J. (1956).

The ninth problem consists of a puzzle composed of nine cells (3 X 3 array) where one cell is blank. The contents of the blank cell must be selected from four possible answers which are displayed on screen. This problem evaluates the role of perception in problem solving involving dual pattern recognition. Results of this task enhance the validity of inferences drawn from performance on problem eight, where statements are made about the influence of cognitive strategies upon performance.

Instrument #2: Moral Reasoning

This test consists of two parts. Part one consists of five questions assessing developmental stage of Moral Reasoning on issues of Justice (Kohlberg)[1]. Part two consists of five questions assessing developmental stage of Moral Reasoning on issues of Care and Responsibility (Gilligan)[2].

The Kohlberg dimension of the test is indicative of the level of development of the notion of Justice, an important factor in social responsibility. The Kohlberg approach suggests instructional techniques which are more directed than those suggested by "Values Clarification". The latter prescribes ". . .raising students' consciousness of values . . . " but ". . . creates additional values and moral questions because students quickly recognize that values often conflict . . . . What the values-clarification model lacks, then, is the ability to help students cope with value conflicts."[3] The Kohlberg approach allows for development of commonly agreed upon broad based social ethics whose foundations transcend specific cultures. However, within Kohlberg's Justice dimension are four factors in which decisions made by subjects vary as a function of ethnicity (Black, Chicano, Anglo).[4] Those are: retribution vs. restitution; immanent justice; moral realism; and communicable responsibility. The development of notions of Justice in social ethics thus varies with cultural/ethnic group; most likely as a function of qualitative values[5]. Investigation of how cultural and other qualitative values interact with Moral Reasoning has significant importance for STS Science Education..

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[1] Hersh et. al. (1979).

[2] Gilligan, C. (1977).

[3] Hersh, op. cit.

[4] Cortese, A. (1982).

[5] Understandings of Justice which relate to enforcement of law upon ethnic minorities in inner city areas are included here as "qualitative values". Such understandings have impact on understanding of "normative values"; and impact the selective use of cognitive structures. A Black youth in the inner city expresses greater expectation of attributed "guilt by association" (communicable justice) than Anglo youth; and each engages different processes.

Limitations of Kohlberg's approach are pointed out by Gilligan[1], who states: "The values of justice and autonomy that are presupposed in current theories of human growth and development and embedded in the definitions of morality and of the self imply a view of the individual as separate and of relationships as either hierarchical or contractual . . . In contrast, the values of care and connection . . . imply a view of self and other as interdependent and of relationships as networks sustained by activities of care-giving and response." By expansion of the developmental model to be inclusive of ". . . two moral predispositions (which) inhere in the structure of human connection . . . towards justice and towards care . . ." , the developmental model is expanded to include a larger population (particularly women, the elderly, and ethnic minorities). In Gilligan's model, level of development is assessed in terms of progression through judgements rendered on the basis of focus on self, the concept of responsibility as the basis for equilibrium between self and others, and the assumption of the role of arbiter of an independent judgement that subsumes conventions of both individual needs and equilibrium between self and others under the moral principle of nonviolence.

Gilligan's contention that Kohlberg's model is culturally and gender biased is supported by research findings.[2] Ethnic differences favoring Anglo males are found when using the Kohlberg dimension of Moral Reasoning and may be attributable to a cultural bias where formal reasoning is favored over humanistic reasoning by that group; or, ethnic differences may be attributable to SES related qualitative values; or, both.

Part two of the Valuing and Moral Reasoning test assesses Gilligan's Care and Responsibility dimension. Performance on that dimension is indicative of level of development of the Humanistic facet of Moral Reasoning. Combined, these two dimensions of Moral Reasoning provide good measure of the development of normative values, and provide opportunity to investigate interaction of those with cognitive processes and qualitative values.

A third dimension of Valuing and Moral Reasoning, not evaluated with this test, is defined by Bruner[3]. He maintains that ". . .

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[1] Gilligan, C. (1986).

[2] Cortese, op. cit.; Gilligan, (1977).

[3] Bruner (1986) proposes that Values and Moral Reasoning are not developmental questions to be studied empirically, but questions of Moral Philosophy. Piaget proposes that qualitative values, as distinct from

morally justifiable positions that can be derived . . . from suitably formulated axioms . . . have nothing to do with what (developmental theorists) learn about the nature of formal operations, peak experiences, or ego functioning (p. 20)." In a technological and scientific society, logic and mathematical thought is culturally valued, and stages of moral thought which have been ". . .unearthed or constructed by modern theories of human development come to be canonized as desirable realities if they conform to values already independently in being within the culture (p. 24)." Bruner proposes that ". . . showing the different value positions that people can take and still maintain a kind of intrinsic dignity . . . (provides an) . . . interesting menu of possibilities. . . . and that makes me political as well as a scientist." (p.32).

Bruner considers education to be culture creating rather than culture transmitting. He proposes that a meta-theory of values concerning the cultivation of the good of man and the good of society is necessary if we are to avoid becoming the handmaiden of implicit beliefs in the culture rather than vigorous participants in the debate about the values for the next generation. A pluralistic value system derived from comparing, within an axiomatic system, the fruits of differing value systems provides an awareness of alternative ways to live out careers and to manage the environment in support of chosen careers. In that context, culturally prominent values such as formal level technical expertise and scientific reason, have no priority over creativity, spontaneity, fantasy, and socially contextualized thought characteristic of the preoperational or concrete operational stages of development.

Bruner's ideas provide a framework for understanding and evaluating qualitative values. That framework is particularly well suited for examining interactions between cognitive processes and qualitative values since Bruner clearly distinguishes between each and provides means of evaluating both. In addition, his approach is compatible with Piaget's model for understanding interactions between cognitive processes, normative values, and qualitative values. Finally, the Bruner framework provides a reference point (. . . "awareness of alternative ways to live out careers and to manage the environment in support of choosen careers") which connect STS goals; Cognitive, and Moral Reasoning theory; and qualitative values.

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normative values, do not rely upon cognitive structures but rather form content in the use of structures. These ideas are compatible.

Conclusion

Enhancement of educational opportunity for minority students requires a multifaceted approach towards addressing factors associated with underachievement. Those factors are Socioeconomic Status, Stereotyping and Role Models, Attitudes and Aspirations, and Cultural Values. Addressing the problem of Socioeconomic Status is a complex issue, but one which is addressed indirectly by education through the remaining factors. The factors of Stereotyping and Role Models may be addressed by avoiding arbitrary ethnocentric and androcentric values in programs and instruction, by including minority group scientists and inventors in science and technology studies, and by regular use of minority community leaders as guest speakers or partners in activities. The factors of Attitudes and Aspirations must be addressed with a variety of techniques. Effective Schools management and instruction techniques, to enhance knowledge and understanding in an environment which nurtures fundamental academic success. Problem solving and open inquiry techniques, where creativity, mature independence, and responsible decision making are nurtured. Techniques of partnerships with parents and community, where the relevance of education to enhancing the quality life is realized. In concert with these, a focus on cultural values must be included in STS Science Education if minority students are to become franchised members of our technological society. The assessment instruments discussed in this paper subsume both the goals of STS Science Education and values. By presenting a framework within which science process skills, broad based normative values, and culturally varied personal values may be viewed in common context, these assessment instruments enable designers of programs and instruction to give due consideration to cultural and personal values. This focus presents one more opportunity to address the multifaceted problem of enhancing educational opportunity for minority students.

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TURNING MINORITY STUDENTS ON TO SCIENCE CAREERS: THE PURDUE UNIVERSITY MODEL

Irene H. Johnson

More than three decades after the civil rights movement broadened the effort to provide equal educational opportunities for all, minorities are still severely underrepresented in mathematics, the natural sciences, and engineering. Considering the projected increase of minorities in the population, we must question our future ability to corporate in an increasingly technological world. We need to identify precollege minority youth with an interest in mathematics, science, and engineering, so as to motivate and prepare them for professional success. Lack of knowledge regarding opportunities in these areas and the high school preparation required for success have kept the numbers of graduates at a low level.

Perhaps one might concur with the modification of the Julia Clark article, "The Status of Science and Mathematics in Historically Black Colleges and Universities," that as we develop into a technocratic society, education in the sciences, mathematics, and engineering becomes a paramount concern (Clark, 1985). It is for the collective benefit of society that representation of minority groups earning degrees in these fields be increased. If the situation is not corrected, this society will suffer immensely because it will be robbed of potential producers of new technology and citizens capable of functioning in their and in our world.

Science and engineering workers are vital to our advanced industrial society. But by the year 2010, we could suffer a shortfall of as many as 560,000 science and engineering professionals. As a result, America's economic strength, security, and quality of life are threatened.

The percentage of young Americans preparing for careers in Science has been declining steadily. Our most experienced scientists, recruited after Sputnik, will be retiring in the 1990's. Meanwhile, by the year 2000, the number of jobs requiring college degrees will increase dramatically. The educational pipeline, from prekindergarten through the Ph.D., is failing to produce the scientifically-literate and mathematically-capable workers needed to meet future demand. Analysis of the 4 million students in the tenth grade in 1977 revealed that approximately 9,700 or 24 percent are expected to attain the Ph.D. in Science and Engineering (National Science Foundation, 1988).

America is changing particularly in the composition of its young. Blacks and Hispanics are now 25 percent of our school children; by the year 2000, they will represent 47 percent. Currently, America is a different country demographically from the one that produced earlier science accomplishments. By the mid-1990's, there will be fewer young people to enter the workforce, and these scarce young workers will have to be highly productive to keep our economy growing and maintain our standard of living. This means they will have to be versatile and well-educated, and if we are to continue as an advanced industrial society and world leader, many must join the science professions.

Since the early 1980's, the proportion of U.S. freshmen entering science majors in college has been consistently declining. The drop has not been obvious because many foreign students have been enrolling in this area; colleges also have been making up total enrollments with older and part-time students who tend to graduate in non-scientific majors. A persistence of these trends will result in fewer U.S. Bachelor degree holders and, subsequently, even fewer Ph.D.'s in science.

The table below lists the downward trend of enrollment in the School of Science at Purdue University.

School of Science Undergraduate Enrollment

Year	Total	Black	Hispanic
1983	3674	96	55
1984	3639	82	53
1985	3383	73	58
1986	3101	70	53
1987	2921	75	60
1988	2966	79	56

We must find ways to bring many more young people, particularly those from underrepresented groups into Science. They must receive sound mathematics and science instruction in school, aspire to college, qualify for these majors at college, and complete their degrees. More baccalaureates must stay on as graduate students, as postdoctorals, and as teachers of future science students.

Since the summer of 1986, the School of Science at Purdue University has sponsored the Minority Summer Science Program. The purpose of this project is to increase the number of minority students who are accepted to the university pursuing science majors and to increase the percentage who successfully complete degree requirements. This will be accomplished through recruitment of high-ability minority high school sophomores and juniors and through critical skill development to increase the likelihood of successful academic program completion. Positive exposure to the collegiate environment through this residential program will likely impact acquaintances of the participants and serve to motivate other minority individuals to seek higher education. Blacks and Hispanics are special target groups.

The program's primary goals are:

(1) Identify minority high school students (grades 10-11) with an interest in and/or aptitude for a career in the sciences and provide appropriate career information.

(2) Provide a six-day on-campus summer science experience for high school students.

(3) Provide a workshop for the patents of these students to increase their awareness and knowledge of science career opportunities available for minorities and the role Purdue may plan in meeting their educational goals.

Curricular and experiential content of the six-day residential workshop are aimed at preparing student participants for the demands made upon full-time college students; development of specific success-dependent skills; and building confidence in a predominantly white university. Successful black professionals, faculty, staff, workshop coordinators, and counselors are utilized whenever possible in program presentation.

The project seeks 40 academically strong black and Hispanic students who are rising high school juniors and seniors to participate in a six-day residential program on the university campus. Students are selected based upon reported interests, academic achievement, and recommendations received from counselors and teachers of the school system in which the applicants is enrolled. Students are encouraged to apply as juniors and to again participate as seniors.

The program participants must agree to commit themselves to six days of intellectually demanding classes and laboratory experiences. The program's activities stress the development of abstract reasoning skills, problem solving skills, computer programming, chemistry, and biological laboratory skills. Self-reliance, self-motivation, and independence are integrated into every aspect of experiences provided to the students. Tours of campus and private facilities are also provided during the six-day workshop.

Since 1986, sixty-one minority high school students have participated in the Minority Summer Science Program. Evaluations revealed that the students:

(1) Gained a greater understanding of science course work and science careers;

(2) Increased their knowledge about Purdue University;

(3) Strongly agreed that the program was worthwhile and would recommend the program to a friend.

Currently, all students enrolling in the School of Science who are seminar participants are experiencing academic success (defined as in good academic standing and progression through the curriculum). Analysis is being done to provide detailed participant follow-up to assess enrollment at other universities and/or in other majors.

The program has been funded in the past through prospective employer donations, alumni contributions, and university funding. As the program has gained a positive reputation within the state and the midwestern region, the demand has increased. The quality and number of applicants have also risen. Tremendous potential for the expansion of the program exists.

Evaluation of the project is continuous through feedback from student and staff participants, enrollment follow-up, and academic performance. Data are reported below.

Participant Evaluation 1986-1988

A questionnaire was administered on the first day of the program and on the last day of the program. The Sunday Questionnaire was for gathering general background information and plans regarding careers and college. The Friday Questionnaire was an evaluation of the program as well as plans regarding careers and college. The change in plans was measured by comparing the responses to the same questions on both questionnaires. All questionnaires were confidential and anonymous.

Post-High School Plans	College/University	Work	Trade School	Other
Sunday Response (Pre-MSP)	61			1
Friday Response (Post-MSP)	61			1

The change in the desire to attend Purdue University was as follows:

Plans to Attend Purdue	Strong Desire to Attend	Some Desire to Attend	No Feelings One Way or the Other	No Desire to Attend	Strong Desire Not to Attend	Not Sure
Sunday	25	19	5	4	0	7
Friday	25	29	2	1	2	2

Evaluation of Program Impact

Summary of the Impact of the Program Activities - 1986-1987

A. Factors influencing you to choose the college where you have enrolled.

General reputation of institution
High quality program in major field
Location
Experiences visiting campus

B. Program assistance in academic preparation.

Significantly expanded my knowledge
Increased my math (word) problem solving abilities

C. Impact of program on feelings or grades

Increased my self-confidence
Made me feel more comfortable working in hands-on situations
Made me set higher education goals
Made me set higher career goals

D. Participants attending Purdue

1986 Summer Program - 2 participants
1987 Summer Program - 8 participants

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TECHNOLOGICAL LITERACY FOR THE NEW MINORITY

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I want to put forward three ideas:

a. It is critical for our society, not just on grounds of equity but for our national survival, to reverse the pattern of school-related difficulties and failures among members of disadvantaged minority groups;

b. Science, Technology and Society (STS) as a curriculum emphasis has an important and unique contribution to make to the secondary science education of urban and minority students; and

c. In order for STS to make this contribution, it must be shaped to empower the learning of disadvantaged minority youngsters in urban schools, and this involves new role-relations among teachers and school leaders, learners, and members of the urban minority communities.

In what follows I provide additional background, clarification and support for these ideas.

Education and Minority Groups: The Changing Context

In the 1960's and 1970's, the problems of urban minority education were interpreted in the educational policy arena largely in terms of "equity." The educational system was perceived to be doing an acceptable job for the "white majority," but (despite the achievements of the civil rights era) still failing with too many members of disadvantaged minority groups. While considerations of fairness demanded that we do better, minority education was not perceived as central to the economic, political or cultural well-being of our society as a whole.

Policy-oriented social science studies during those years, such as the widely-publicized reports by James Coleman (1966) and Christopher Jencks (1972), considered such questions as whether school could account for variability in academic achievement and economic success in later life. Arthur Jensen and others proposed genetic explanations of minority school failure.

In the 1980's the discussion of minority education has shifted from equity issues to concerns about national survival.

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Partly as a result, policy oriented research has shifted from a relatively passive attempt to account for the pattern of failure to a more active stance -- attempting to identify and replicate success. This is well illustrated in the "effective schools" literature. Ulric Neisser (1986) in a definitive review of recent research has noted the "ecological" character of recent discussions, in which causal efficacy is assigned to the impact of the social caste system, to cultural factors which conflict with the culture of schooling, and in school organization and pedagogical practices which weaken and disrupt student attempts to learn.

Behind this shift in research is the shifting demographic pattern in our nation and its schools, colleges, and workforce.

Changing Demographics of American Education

When I began my stud;y of STS for urban and minority learners in 1985, this changing demographic pattern of American education had not yet assumed the central place it now occupies in policy discussion. Minority education was still largely focused on equity concerns. Its importance for the well-being and even survival of our nation was not yet widely appreciated. The demographic data and their implications for the educational system had just been effectively presented in a report authored by Harold Hodgkinson (1985) for the Institute for Educational Leadership, All One System: Demographics of Education, Kindergarten through Graduate School. The basic demographic facts are now better known, but their implications for curriculum policy are still being digested by educators. In what follows some data are presented and their implications for education brought into focus.

Births. While the white population is failing to reproduce itself, the non-white groups are either holding steady or increasing in absolute terms, and are thus gaining larger relative share of the population. In order to maintain a steady state, the average female must bear about 2.1 children. The birth rate of the white population is 1.7 per female; of Puerto Ricans it is 2.1. For African-Americans the birth rate is 2.4 and for Mexican Americans it is 2.9. So as these children enter the schools and the work force, the demographic patterns in schools and workplaces change.

Where the school age population is increasing, it is due to larger numbers of minority children. Where school population is decreasing, it is due to a declining number of white children.

Age. The minority non-white population is younger. The average age of the white population is 31, African-American 25, and Hispanic 22. This means that the average white female is nearing the end of her child-bearing years while the average Hispanic female is entering hers. So the demographic change noted above will accelerate.

Aging Population. The population as a whole is aging -- the proportion of older Americans is increasing. In 1950 each retired person was supported by 17 workers. In 1992, this ratio will fall to one in three, and one of the three workers will be from a minority group.

Family Status. Normative patterns of family life and support systems for children are changing. In 1950 over 60% of all households with school age children were "typical" households with a working father, a non-working mother, and 2 or more children at home. In 1985 the percentage of households "typical" in this way had fallen to 7%, and was rapidly falling. Indeed, 60% of all school age children will experience living with just one parent (generally a working or non-working mother) before the school leaving age of 18.

The implication is that expectations about the home background and support systems in place for school-age children must be reconsidered and policy changes made to accommodate to new norms.

The nation is also experiencing an epidemic of out-of wedlock births, over half of which are to teen-aged parents. This is not a "minority" phenomenon: while the percentage of out of wedlock births is higher for non-whites, in absolute terms there are more white than minority out of wedlock teen births, and white females are more than twice as likely to have out of wedlock births in their teen years than their counterparts in any other industrial country.

The bottom line results of these changes are:

* Public schools everywhere will have larger percentages of children from disadvantaged minority groups, members of which have experienced and who continue to experience high proportions of school difficulties;

* Society as a whole, and the work force in particular, are changing to have an increasingly larger proportion of people from disadvantaged minority groups; and

* A higher percentage of school children in all groups will come from broken homes and will be born out of wedlock to teen age parents.

This is the challenge to the well-being and survival of our society. When these disadvantaged minority groups comprised a small proportion of school children, workers and citizens, it was possible for large percentages of individuals from these groups to fail without significant harm to the white population. The white majority was able to neglect the concerns of minorities, or even rig the system of educational and economic benefits against these groups, through segregation and job discrimination, without being forced to pay a high price.

But as these groups become a majority of the public school population and a very dominant proportion of the work force, they *eo ipso* become the key to the health of our society in economic, political, and cultural terms. They hold the key to our future. If they fail our American society as a whole fails.

Social and Educational Implications of the New Demographics

How, more specifically, will our society fail if we cannot reverse the school-related problems and failures of disadvantaged minority groups? Following Henry Levin (1986), we may understand the risks in terms of (1) creation of a dual society marked by social and political upheaval, (2) a conflict in higher education, (3) workforce deterioration, and (4) a crisis of taxation and public costs.

1. *Dual Society*. Because of universal suffrage, disadvantaged groups can gain potential political power even if they fail to achieve economic equity. This raises the spectre of political conflict between "haves" and "have nots" organized around racial and ethnic themes. This would impose unbearable strains on our democratic institutions. Leaders such as Jesse Jackson, who have sought to build a rhetoric of coalition and harmony, may be replaced by minority leaders who, trading on the lack of knowledge and education of their constituents, appeal to their frustrations and baser instincts. Meanwhile, many in the white population may once again put forth "white power" advocates such as David Duke. In addition to the obvious inherent evils of intergroup conflict, such a politics of race and resentment also will certainly distract the nation from the pressing and complex issues now coming to the fore in our technologically-dominated society.

2. *Conflict in Higher Education*. As the proportion of school aged students from disadvantaged groups grows, then even with high drop out rates such students will continue to increase as a proportion of the age cohort to be recruited for post-secondary education. Institutions of higher education will have to find ways of recruiting and retaining them, just to meet their minimum enrollment needs and "stay in business. "

However, if school difficulties obstruct the learning of students from disadvantaged minority groups during their secondary school years, then either (a) a large and increasing proportion of the college and university students will experience academic failure in college, or (b) colleges and universities will be forced to shift increasingly to remedial functions and to lower academic standards, creating conflicts regarding the "culture" of these institutions. An early and bitter example of this was the battle over curriculum and standards at the City University of New York following the adoption of an "open admissions" policy.

The existence of academically under-prepared students recapitulates the "dual society" in higher education itself. "Conservative" forces rally to "preserve the character and standards" of the institutions, leading to intense conflict again organized largely along racial and ethnic lines about the appropriate mission, goals, standards, and curriculum of higher education. A recent battle in this war was the conflict over "Western Civilization" at Stanford. Conservatives sought to preserve the notion of Western Civilization as an organizing theme for general education, while many students and faculty members sought to develop a more "universal" conception of our cultural heritage, embracing the contributions of non-white, non-Western groups. Recent racial incidents at Michigan, Penn State, and other major Universities are also tied to the changing demographics and the new importance of non-white "non-traditional" students, with different learning histories, values and educational needs.

From the "conservative" side, victory in this battle means "preserving standards of excellence," maintaining "traditional" curriculum and conventions of academic achievement. Such a "victory" may be expected to have as a side effect intensified inter-group hostilities and intensified resentments among those in the workforce disqualified from college completion, when our economic and political institutions can least bear these strains.

3. Workforce Deterioration. Until recently, poorly educated workers from disadvantaged minorities were frequently able to find jobs with low educational qualifications, especially in the industrial sector. However, this sector of the economy is declining, and the service sector is expanding. The service sector is very heterogeneous in terms of educational qualifications and skill requirements, but it appears to most observers that a growing proportion of the work force is not qualified for emerging jobs. This includes not merely professional and technical jobs, but even the new jobs at the low end of the skill spectrum.

The lack of fit between basic skills and workplace demands places U.S. business and industry at a competitive disadvantage with those of other developed and developing nations. In many international comparisons of academic achievement, especially in science and mathematics, the United States finishes near the bottom. While Japan and Korea can graduate over 90 % of their cohort from secondary school, and effectively convey basic skills and cognitive routines, we can graduate only 70%, many of whom remain functionally illiterate. These facts stunned the nation when publicized by the National Commission on Excellence in Education (1983) in "A Nation at Risk."

It is frequently argued that those entering the workforce in the United States have lower levels of productive knowledge and skill than our competitors, and thus impose higher training costs and lower productivity on business and industry. This puts U.S. industry at a competitive disadvantage in the global technological economy, and that implies a lower tax base, an increasing balance of payments deficit, and a deflated value for U.S. currency. That erodes the value of individual wealth and income, implying a lower standard of living for Americans.

Concern about this is hardly confined to business leaders and conservative politicians. Liberal economists such as Lester Thurow of MIT emphasize the relationship between the "technological literacy" and "productive knowledge and skill" gaps and our trade and budget deficits. He points out that high-tech quality control workers need basics of algebra and statistics to perform routine job functions. IBM must teach its workers this knowledge, while Japanese firms can take it for granted among their entry level workers. The conclusion of this sort of argument is that unless we can reverse our patterns of school failure for the rapidly growing segment of disadvantaged minorities in our schools, the comparative quality of the American workforce will deteriorate further. Thus we will be forced to lower our standard of living either in the present, or, to pay for an ever-increasing foreign debt burden, even more dramatically in the future.

4. Crisis of Public Costs. Civil unrest, educational upheaval, economic decline -- these all impose additional cost burdens for the public. If we cannot reverse school difficulties and failures for disadvantaged minority groups, then our society will have large numbers of alienated and unemployable or marginally employable teens and young adults. These individuals become the welfare mothers, the drug and alcohol abusers, the anti-social, mentally ill and criminal elements of society, and they impose large public costs.

Failure effectively to integrate members of disadvantaged minorities into the economic mainstream of society during the school years places increasing burdens on the taxpayers. The costs of the welfare and criminal justice systems are increasing at the very time when the economy, faced with foreign competition, escalating expenses and increasing debt, can least bear such costs.

The "Excellence" Solution: Raising Standards

A series of national education reports has focused national attention on the poor performance of the American educational system. The first proposed solution to the problem of low academic achievement was advanced under the banner of "excellence." Most of the reports, following the lead of "A Nation at Risk," used the language of "excellence. " In practice, excellence meant raising standards, increasing school hours, emphasizing basics, establishing minimum competencies for high school graduation and minimum competency tests for teachers. National leaders directed leaders at the State and local levels to implement these reforms.

The impact on disadvantaged minority learners was predictable. While Governors put educational reform on the agenda, and state legislatures passed reform legislation, few states appropriated increased funds for improved performance. Standards were thus raised while many minority students were already failing to achieve the lower standards, and no additional assistance was provided. As a result, more minority students experienced frustration and failure and dropped out of school or failed to graduate. Harold Howe II (1983), Ernest Boyer (1984), and other leaders immediately predicted this unintended consequence of the "excellence" movement.

Minority educators were also quick to express their deep concerns. Faustine C. Jones-Wilson (1984) wrote that:

> The clear danger to blacks is that we might be ignored in the quest for excellence and quality since so many power holders seem to believe us incapable of attaining the highest standards of mental performance... (p. 98).
>
> Black students are failing competency tests in larger proportions than their white or Asian counterparts, and in some communities their Hispanic peers. As a result these youth will receive school attendance certificates, not high school diplomas, and will be unemployable unless remedial education and retesting are provided them.
>
> Black children, their parents, and their organized groups need to understand that the current mood is to test them out of the educational and employment pictures. It needs to be understood that the competition has increased for scarce places in education and employment ... The feeling is that people should merit education and employment opportunity, and merit is more than often determined by test scores (p.109).

The solution to the problem of education for disadvantaged minorities does not lie merely raising standards of achievement, although achievement will of course improve as the problem is addressed in more effective terms. As Boyer put it, "schools have less to do with "standards" than with people."

Redefining the Problem

The problem of education for disadvantaged minorities needs to be redefined in terms of people, their perceptions and needs.

To begin this process we must recognize that thinking about the problem in terms of "ethnic minorities" is misleading. This term focuses on cultural difference (ethnicity) and low percentages of the over-all population (minorities). These factors are no longer central to the problem in the way they once were.

Before the civil rights era there was blatant social, political, economic and cultural discrimination in our society, North and South, supported by custom and law. This pattern of historic racism imposed a stigma upon non-white minorities, involving denial of the right to vote and participate in civic life, the imposition of a job ceiling and the assignment of low status employment, the denial of equal protection of their laws, prohibition of social relations, and invidious comparisons of cultural activities and products.

In the years after the civil rights movement and civil rights legislation, historic racism and its associated stigma has been, while not ended, reduced and altered.

There are new opportunities for many members of once stigmatized non-white groups in education, in politics, in cultural life, and throughout all sectors of the economy including the professions, business and industry. This is one of the most significant facts of our times, but like most important "pluses" it has unintended "minuses."

One "minus" in the new situation is that those left behind face more difficult problems, with fewer supports. As individuals from the once stigmatized groups avail themselves of emerging opportunities, they move out of ghetto neighborhoods and the isolated "minority" community, and enter the "mainstream." To the extent that they do so on equal terms, with their cultural identities intact, they inter-act with members of the white population and continue to forge a more "universal" culture which partakes of the dynamic interaction of various ethnic groups in the mainstream.

Now we face a new problem of "residual" out-of-the-system individuals caught in the inner cities. This is not a problem of "ethnic minorities" but of people without essential social resources. As those more capable of making, and keen to make, an accommodation to the educational and economic mainstream leave the disadvantaged communities, those left behind in the inner cities remain in situations increasingly emptied of individuals striving to succeed in the normative pattern of hard work and delayed gratification leading from educational achievement to economic success. This means, in the residual communities there are fewer models of success through the "work ethic," people who are working, achieving, becoming economically, culturally socially and politically affiliated. The very serious problems of those who remain in isolated "ghetto" conditions are no longer simply problems of race or ethnicity.

The problem which remains is not one of aspirations but of means for achieving them. Studies have shown that the aspirations of ghetto youngsters are not any lower than middle class youngsters in suburbs. What ghetto children lack are clearly demarcated pathways to success, to the achievement of their aspirations. What they lack are not "middle class values," as much as middle class resources.

The demarcation of success pathways has never been entirely or even predominantly the business of the schools. Family and community goals, models, and support systems have always been primary. Different groups have used the schools in somewhat different ways to achieve entry into the mainstream. The schools provided paths for these groups, but the groups had to search for and then light these paths, so to speak, with cultural factors (goals, support systems, models, work ethic) they themselves provided. The schools were instruments which in different ways served the somewhat diverse purposes brought to them by various groups.

There is no "culture of poverty" if this phrase implies the disadvantaged groups lack aspirations to succeed. Instead there is a "poverty-dominated culture" among the residual disadvantaged population, in the sense that the support systems, models, and work ethic needed to use the schools for success have all eroded as the most school-adaptable members of these groups have entered the mainstream and left the ghetto.

Among inner city residents, school children and their parents and neighbors, schools are not widely perceived as pathways to success. On the contrary, as John Ogbu and James Comer have each documented, the school is frequently perceived by the ghetto community as a hostile force. Because of the performance of the educational system in the era of historic racism, when schools for disadvantaged minority groups were frequently rigged for failure, these perceptions have considerable historical justification and cannot be dismissed as mere paranoia.

But reactive perceptions add to the problem. Many have written about the ghetto residents feelings of being trapped. For many school children, school itself is a trap laid by the white population. Ghetto students speak of school effort and success as "the whiteman's way." This way of thinking blinds young people to the opportunities which may exist in their school situations. As John Ogbu puts it, the reasons for minority school learning difficulties are to be found " both in the ways the wider society (including the schools) treats the minorities and the way the minorities themselves respond to the treatment (Ogbu, 1985, p.864). His data suggest that Black children begin to internalize a distrustful attitude towards schools early in their school careers, and he notes that children with such an attitude have greater difficulty accepting and following school rules of behavior for achievement.

To summarize to this point: the school-aged children and youth and their parents have high aspirations for success but lack clearly demarcated pathways. They frequently see the schools as pathways to disappointment, frustration and failure, not success. Such perceptions can lead to reactive attitudes and behaviors which obstruct school commitment and academic achievement.

The problem of school commitment is compounded by the existence of a well-elaborated "oppositional" cultural alternative -- which, as Ogbu notes, includes different styles of talking, thinking, feeling and acting. One important dimension of this alternative is the street culture and the "gang," with its associated behaviors of truancy, delinquency, petty crime, and violence.

The gang is certainly among the most misunderstood and devalued of social forms in the popular mind, but sociologists have frequently pointed to its positive as well as negative features, including loyalties, fraternity, socialization of group norms in an otherwise normless situation, etc. The gang and its associated pattern of delinquency is also a form of economic activity and a pathway to the criminal economy.

In large cities the gang culture affects, in large ways or small, the lives of almost every inner city young person from early teen through late teen years (Kinsburg, 1975).

For many young people the question is "which way is right, street or school? " The children rely upon one another, and breaking with their peer culture is very threatening. To be marked as a "Tom," as going the "whiteman's way," is to face ostracism from the one system that provides meaningful support, clear norms and demarcated pathways of life. As Ogbu states the point:

Inner-city black youngsters and similar children may define

> academic success as more appropriate for whites; therefore minority students who do well academically are regarded as "acting white" or "strange" and are subject to peer pressure to change. The dilemma is ... that they often feel forced to choose between doing well in school and manufacturing their group membership in good standing (866).

As Dr. Cora Turpin, a senior science teacher in Philadelphia and one of our project associates put it, the kids have "nobody to fall back upon; life for them is a singular effort. The peer group is crucial to survival, and the kids must accommodate to their peers. They are tortured for setting high academic standards." And Maria Arguello, also a senior science teacher and project associate, added: " the kids depend upon one another for support and even survival. So looking good in front of peers is crucial. If teachers threaten their image with peers, they are threatening their very survival."

Ogbu draws the conclusion that at the level of practice, teachers and schools need to "develop programs to help these minority children learn how not to equate mastery of school culture with loss of group identity and security (Ogbu, 1985, 868, his emphasis).

The problem is further compounded by unequal provisions for educational finance, the growing shortage of superior teachers who can penetrate the inner world of the ghetto youngster, and deteriorating school buildings. These send a message to the students that the system doesn't care.

To draw the main implications of this section:

The problem of "minority education" does not reside in either ethnic differences or in the small relative proportion of these groups in the population. The groups are growing in size and importance, and with the decline of historic racism many members of these groups are entering and making major contributions to the mainstream society. We are now faced with a new problem: a growing population of individuals left behind despite the inroads against historic racism.

This problem is not a "technical" problem" of finding the "right educational methods" to teach disadvantaged youth, and especially not a problem about "low academic abilities."

The problem is not really "how to teach these kids" at all, but the prior problem of "how to win their hearts and minds." This can only be done on terms which are understandable, believable, and appealing to them. Very little going on in comprehensive high schools now can meet this test.

Mary Ann Raywid puts this point well:

> There is obviously a serious mismatch between many of our high schools and the students they are supposed to be serving. We must change that and change it soon. If we are serious about wanting to keep prospective dropouts in school, then clearly what we must do is change the way they feel about school. They have to be convinced that education is of value, that it is worthwhile and can make a difference in their lives.
>
> It is the simple fact that they hate school... so that if we want to keep "at risk" youngsters in school we are going to have to provide a different kind of school environment...a different kind of place, with a different kind of organizational structure and a different feel and flavor.

There is no way to simply "whitewash" this problem; rather we must change the relationship of school, learner and community in very fundamental ways. We have to make the relationship work, so that it can maintain learner commitment despite the large demands it places on the learners, along with frustrations and occasional setbacks. What might this look like, and how can STS play a role?

Domination, Advocacy, and Empowerment

There are several conceptual frameworks in the literature for understanding the educational problems of disadvantaged minorities. Our project associates found those which centered on the themes of domination, advocacy and empowerment (Cummins, 1986; Ogbu, 1985, 1986) particularly relevant. They also saw a need to augment these ideas to emphasize the active role of the learners in resisting (not merely being disabled by) inappropriate school routines (Welsh, 1987)

To such researchers as John Ogbu and Jim Cummins, the school problems of disadvantaged minority members lie in the reestablishment in school of the very forms of social relationship in the larger society which dis-empower these youngsters, de-valuing them and weakening their energies for school learning. Whatever other changes may or may not be appropriate in the curriculum content, primary reform is "dependent on educators, collectively and individually, re-defining their roles with respect to minority students and communities (Cummins)." Role definitions and structures in the classroom, and the dynamics of role interactions, either empower or disable learners.

Cummins conducted analyses of cross-national empirical data on the academic achievement of individuals in low status groups. His research indicates that educational programs for such groups are successful to the extent that:

(1) minority student language and culture is incorporated in the school program;

(2) minority community participation is encouraged as an integral part of the learner's education;

(3) the methods of pedagogy promote intrinsic motivation on the part of students to use language actively to generate their own knowledge; and

(4) professionals involved in assessment become advocates of learners rather than legitimating the location of the "problem" in the learner.

On this analysis the problem resides not so much in the <u>content</u> of the school curriculum, as in the relational <u>context.</u> Useful change will not result from new curriculum content but only from a more "user friendly" context for schooling. The message to learners and community residents must be: the schools are here to assist us in improving our lives, expressing our `unique personal and cultural identities, and solving our common problems.

Trubowitz notes that the feelings of young people are a "facet of all curriculum content," and that youngsters will not accept or become involved with curriculum content that does not take their feelings into account." But when they "sense that their vital needs -- as represented by their inner emotions -- are understood and dealt with, then communication and cooperation are encouraged (Trubowitz, 1968, p. 92).

A contextual change does not necessarily demand a wholesale revision of curriculum content. From a practical standpoint that is a good thing, because minority education leaders tend to reject wholesale curriculum content revision. They do not want minority children to be guinea pigs for educational experiments, but rather want the same "quality" education which in their view has worked for the white children who have experienced educational and economic success. When a user-friendly relational context is established and communicated convincingly, much of the old curriculum content can be reconfigured and infused with new meaning and relevance. This applies to many components of the discipline-based science curriculum, as the American Chemical Society's CHEMCOM (Chemistry in the Community) course amply demonstrates.

The New Social Contrast of Schools and STS Education

What is the relationship between the new relational context prescribed by Cummins and STS as an emphasis and organizing theme in science education?

1. Minority Language and Culture. Language is the heart and soul of the learner. Language (reading, writing, thinking, speaking, listening and interpreting) is not merely a "skill," but rather it is voice, spirit, soul. Language implies deep cultural roots transformed through personal self-expression and construction of meaning.

As William Labov (1972) and others have demonstrated, Black American English is a highly subtle, nuanced, and expressive language. The issue our project faced was not whether Black or "Standard" English, or Spanish, etc., should be used as the language of instruction. Even if so-called standard English is used in instruction, the native language of the learner must still be understood and valued. As Charlotte Brooks has said, to deny the child's language is to deny the child.

Barry Kinsburg has emphasized that the gang and street culture is, as much as anything, a context for expressive language use. The leader of the gang is given the title of "runner," and Kinsburg notes that in Black ghetto argot, to "run it" means to talk or tell a story. He adds:

> The runner may be thought of as the "talker" or "story teller." Several gang researchers have stressed the high value placed on verbal ability by adolescents... Members of gangs feel that verbal ability is a central characteristic of leaders....Runners were the leaders of the daily routine. On the corners, we observed that leaders would often be in a center of a close semi-circle of gang members dominating the conversation of the group (Kinsburg, 1975, 66-7).

However, the verbal ability of the "runners" and other inner city youth may not be detected by mainstream professionals or standardized tests.

Kinsburg provides the telling example of one prominent Philadelphia gang "runner," "Deacon." Two psychologists who examined him had a dim view of his abilities. The first reported Deacon's verbal IQ to be 87, and his reading level at age 17.2 to be 1.7. His report called Deacon "slow-functioning" and stated that "in verbal efforts the boy indicated substantial limitations." The second psychologist ended his report by asserting that Deacon "appears without talent of any kind." (Kinsburg, p. 19).

Yet Kinsburg's own observations of Deacon contradicted these reports:

> A debate with him required a great deal of skill, but even then one could never expect to have the last word. Other gang leaders, when asked why Deacon dominated, ...stated " Deacon can rap for us: he knows what we feel." He displayed a quick and subtle mind, and was a great creator of phrases... He was the elaborator, the teller, the one who would explain at length, and almost without argument, the thinking and feeling of the group. (Deacon was) the center of attention, telling jokes, engaging in verbal repartee....and performing an almost continuous monologue about the real and mythical activities of fellow gang members.

Such reports from the field should help us to understand why youngsters associate the culture of the school, and its aura of language constraint and correction, which they contrast with the expressive street culture, as a kind of personal and cultural homicide -- they feel dead in school; as Raywid insists, they "hate and detest" the school experience.

Sidney Trubowitz (1968) notes with irony, that " children who can insult each other with a neat turn of phrase are not totally without language ability." He adds: "the use of highly figurative language, understood only by the initiated, may be the children's way of showing their power over society and authority." (p. 89).

STS issues, with their focus on values, on diverse cultural definitions of problems, and on diverse solutions based on the use of cultural resources rooted in diverse traditions, are a channel through which expressive language can flow. Young people can express their ideas, wishes, hopes, and plans, and discover that these are regarded as interesting, important, and "on target." Learners can give vent to their feelings of anger and frustration, and their need to have a greater control over their environment. Through this process, they can see that their own language permits an enjoyable play of imagination which is accepted and admired in school, that there is an adult audience for their experiences and hopes, and as Trubowitz (p. 89) puts it, " an acceptance of the idea of possible change."

2. Active Community Participation. Cummins notes that community participation must be encouraged as an integral part of the learner's education. This contrasts sharply with the invidious comparison between the "civilized" culture of the school and the "barbarians" beyond the gates. It implies acknowledgement of the value and worth of viewpoints in the community. It means opening up the wall of separation between school and community, so that much learning is "community-based"

and places youngsters in contact with adults in the community. And it means making the school a significant resource for the adult community, through continuing education, information and public awareness activities.

It does not mean "token" participation to satisfy some bureaucratic demand for participation, e.g. a rubber stamp parent curriculum committee. Empirical studies show that such forms of participation have no impact on school achievement, and we should hardly expect that they would.

Encouraging participation depends upon (a) recognizing that life in the disadvantaged minority communities has some positive elements which are educative in the best sense, and (b) making the problems of living in the community a relevant and important focus of learning.

STS education provides several means for enhancing relations between the school and the minority community.

Issues such as solid waste management, chemical pollution of the air and water, urban health problems, changing workplace quality and declining industrial jobs, high-rise housing, noise pollution and crowding, heroic measures to save low weight babies, AIDS, and illicit drugs all bear on urban youth. STS units on such issues can draw upon the learners' experience of their urban environment and enrich it.

As Trubowitz notes:

> Children are in daily contact with other city agencies. They include the Park Department, the Department of Sanitation, the Rapid Transit System, the Department of Gas and Electricity, and the Department of Water Supply. By focusing on the work of city agencies, by arranging for more personal contact with these agencies, and by exploring in depth the effect of agency work, the school can help the children develop a clear understanding of this aspect of the world around them.

Leaders within the community, representing the professions, city administration, and community groups can be called into the classroom to address urban issues. Or students can learn about these problems at first hand through community-based learning activities.

The school can sponsor STS "short courses" and "briefings" so that parents and community residents can gain in awareness about the problems facing their communities. Community leaders can participate in such efforts, building support in the community to address problems by political action. By such participation, members of the community can strengthen their ties of loyalty and support for their schools.

Students can also learn actively to seek solutions to problems they have passively endured, and their own learning activities can be part of the solution, e.g. in an environmental campaign.

3. Intrinsic Motivation to Use Language Actively to Generate Knowledge. This component implies that youngsters learn through defining situations in their own terms, defining problems and proposed solutions in terms of their own cultural values. It takes "active language use" to the level of "knowledge." This means breaking the cultural stereotype of knowledge as a static entity expressed in a foreign language in a textbook. It stands against the shaping and constraining of language implicit in passive text-book learning and the one culturally defined "right answer."

STS units contribute directly, because in them the focus of "knowledge" shifts from the "text-book" problem and the one right answer to real problems encountered in the community. Their own direct experience and that of community residents, their interpretations, analyses, and different solutions are relevant "knowledge."

4. Assessment for Advocacy. This kind of assessment means that the "evaluator" is open and actively seeks out the power, elegance, simplicity, intelligence, courage and other virtues in the responses learners actually make to situations which concern them. This compares with the gate keeper notion of evaluation, based on behavioral objectives, standardized tests and minimum competencies, the red pencil and the failing grade.

Assessment for advocacy means defining the educational situation holistically, in terms that learners find convincing, and with goals which are personally meaningful, however demanding. It goes beyond "judgment" and "standards" to actively discover worth and merit in the learner's mode of approaching the tasks at hand, building on what is positive and correcting what is negative in clear but non-judgmental terms.

STS education lends itself to this mode of assessment, for its goal is not inert knowledge but the active participation and empowerment of learners.

STS in Secondary Science Education

STS education is one already established curriculum emphasis in science instruction. It is not a new invention geared for "low ability" students, but rather an innovation for all students which has won the enthusiastic endorsement of the leading professional associations and government agencies such as the National Science Teachers Association, The American Association for the Advancement of Science, and the Science Education Directorate of the National Science Foundation.

As defined in the literature of science education, and implemented as a curriculum emphasis, it lends itself well to the changed role-definitions summarized above.

Among currently authorized curriculum reforms in science education, it is the only one which does so. For this reason STS is the best currently available window for such reforms in the established science curriculum. This is its unique contribution.

However, in urban schools STS must be implemented so as to emphasize these new role-definitions. Unfortunately, many ways of implementing STS fail to achieve this potential. The STS unit on "acid rain," drawing heavily on knowledge and concepts unfamiliar to urban learners and approaching a problem far from their experience or concerns, presented as authoritative knowledge by teachers to passive learners expected to learn the right answers, will not make any difference in inner-city schools.

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The use of Commercial Software in Problem Solving: dBase III+ and the Chemical Elements

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At Iona College (New Rochelle,N.Y.) a general education requirement entitled Scientific and Technological Literacy (STL) has been in effect for approximately seven years. STL is a two semester sequential requirement which focuses upon various thematic areas of a scientific nature; the areas are concerned with health, energy , or environmentally related topics depending upon the sequence selected by the student. Since the college population serviced by the STL sequence is composed of non-science majors, an important aspect of the STL courses is associated with fostering the ability of the students to approach and confront scientific problems, and to do a bit of "problem-solving".

A segment of the STL problem-solving component has involved use of the microcomputer along with commercial software packages in order to analyze aspects of the theme related problems. In particular, attention has been devoted to application of spread sheets in terms of problem solving via simulation, modeling and data reduction. For example Lotus 1-2-3 and/or VP-Planner have been used to:

1. Analyze and simulate population growth under changing conditions of reproductive and mortality rates(1).
2. Examine some of the consequences associated with diagnostic screening tests in terms of society and monetary costs (2).
3. Project national gasoline consumption under various conditions of fuel efficiency and miles driven (3).

In addition to application of spread sheets to problem-solving, it appears that database software such as dBase III+ can also be used to simplify and correlate data regarding certain kinds of scientific or technological problems. For example epidemiological studies involving several possible causative factors, or the degree of impact of hazardous waste on the environment may be readily examined and organized using an appropriate database and data base software.

In an attempt to illustrate the application of dBase III+ to problem solving, as a first exercise, a data base may be created utilizing the chemical elements along with a number of physical and chemical properties of these elements. The structure of this database as well as a portion of that data appear on Tables 1 and 2 .

The database (with some modification) and the correlations associated with it, parallels the problem which confronted Dimitri Mendeleev over one hundred years ago when he successfully deduced the periodic law and developed the periodic table from the unorganized elemental data. Of course the basis for Mendeleev's successful solution to the problem of "chemical organization" resided in his discovery of the periodic law (the physical and chemical properties of the elements are periodic functions of their atomic weight (atomic number)).In short the key step in the discovery of the periodic law was based upon the organization and correlation of a chemical database.

In a similar way students are asked to place themselves in a situation analogous to that which confronted Mendeleev. The students are provided with a listing of the chemical elements and some of their selected properties; they are asked to use dBase III+ to create a database and correlate the elements and properties (fields) within the database via sort and/or query commands.Depending on the students'chemistry background (most are unaware of the periodic law) different periods of time are required in order to create the appropriate basis for correlation. Ultimately the student can verify the periodic law and correlate the data by sorting the elements according to atomic number (or atomic weight, or period and group). Table 3 illustrates the database sorted according to atomic number. If one focuses upon a particular property (such as electronegativity, ionization potential, or atomic radius), a periodic variation may be discerned from the data. A plot of this data , however is much more revealing and serves to convince the student of the validity of the periodic law. Graphs of atomic number vs. atomic volume (Figure 1) and ionization potential (Figure 2) illustrate this point.

In order to achieve a plot of the data, a Lotus file must first be created from the data base file; Lotus is then used to create a graph. The Lotus file can be generated from dBase while in the dot prompt mode. The command:

```
Copy to (filename) wks
```

will create the Lotus file.

dBase may also be used in connection with this database study to correlate elemental properties within a group or period as noted in Tables 4 and 5. Finally one can explore and make new connections between the elements and their properties or use the database to discover which elements would fit a particular set of requirements. For example properties of elements related by density, electrical or thermal conductivity, and liquid temperature range might be of importance and could be quickly established via dBase commands.

It may be noted in closing that a commercial version of the periodic table database exists (JCE:Software publisher); however in STL course work it is the development of the problem solving capability which of major importance, and requires knowledge of an approach to data analysis and reduction rather than specific software for a specific task.

A copy of the dBase exercise is appended.

References

1. Levkov Jerome S., "Applications of Commercial Spread Sheet Programs in Science Education",Third National STS Conference Technological Literacy, Arlington, Virginia February 5-7, 1988.

2. Murphy,James J., "Uncloaking Judgments Underlying Technology: Example of Medical Screening Tests", Twelfth Annual Humanities and Technology Conference, Marietta, Georgia, October 20,1988.

3. Huang, Ming , and Campisi, Louis S. "Pursuing the Study of Energy Problems: Fuels for Transportation",STL Conference,Iona College,New Rochelle,New York April,1987,

dBase III$^+$ and the Chemical Elements

This is an exercise utilizing dBaseIII+ as an approach to problem solving, using some of the physical and chemical properties of the chemical elements as a database source. The Russian chemist Dimitri Mendeleev over one hundred years ago , using a rather sparse "database" , was able to make correlations between the elements and their properties. This exercise provides you with an opportunity to duplicate Mendeleev's efforts using the microcomputer and the commercial software, Lotus 1-2-3 and dBase III+. In the event you are not familiar with either or both of these packages consult your instructor for an explanation regarding use of this software.

1. Create a database using the structure listed according to Table 1. Call the database ALFASORT.
2. Input data into the database according to the data supplied in Table 2.In the event time is short your instructor will allow you to copy the database directly on to your disk.
3. Try to correlate the property of the elements in the data base using any sorting or query commands you deem appropriate.
4. Mendeleev discovered that the physical and chemical properties of the elements are periodic or recurring functions of their atomic weight.(Actually it is the atomic number, or really the number and arrangements of the electrons which influence the periodic variation of the elements' properties).
Sort your database according to atomic number of the elements.Call this file ATNO. Obtain a print out of this file and see if you can now discern the periodic variation of some of the properties. Create a report form where the properties listed are element name, atomic number,atomic volume, period, group, and ionization potential. Obtain a print out of this report.
5. Create a database file in which only the properties, described in the previous paragraph are listed, by using appropriate query commands and sort according to atomic number. Call the file ATNOVOL.
6. Load ATNOVOL into dBase (make ATNOVOL active). Go to the dot prompt mode.
Type the following:

```
    COPY TO ATNOVOL WKS
```

You have just created a Lotus file of the dBase file ATNOVOL
Quit dBase . Keep your data disk in the B drive.
Load Lotus in the A drive. Using Lotus make the B drive active and load the Lotus file you have just created.
It will be found under the name ATNOVOL.WKS. Create a graph in which atomic number is plotted on the x axis vs atomic volume. Create a second graph in which atomic number is plotted vs ionization potential.Obtain a print out of these graphs.
7. Quit Lotus. Load dbase. Create a report listing selected properties of the elements within the same group (use group I).
8. Create a report listing selected properties of all elements with some metallic properties within the same period (use period 3). In both cases observe the variation of properties of elements listed
9. Explore possible connections and correlations between the elements and their properties

10. As a final exercise compile a listing of all metallic elements of density less than 1.5, having a melting point below 200^{0}C and an atomic weight greater than 20.What correlations can you make concerning these elements?
11. Hand in the structure of the initial data base, the data bases ALFASORT,ATNO,ATNOVOL,the report of ATNO,the two graphs, the two tables of the elements (listed according to Group and Period) and the table defined according to the paragraph (10) above.

Table 1

```
Structure for database: B:ALFASORT.dbf
Number of data records:       54
Date of last update    : 01/01/80
Field  Field Name   Type        Width    Dec
    1  ELEMNAME     Character      11
    2  ELEMSYM      Character       3
    3  ATNUM        Numeric         4
    4  ATWT         Numeric         5       1
    5  IONPOT       Numeric         4
    6  ENEG         Numeric         4       2
    7  RAD          Numeric         5
    8  ATVOL        Numeric         5       2
    9  DENSITY      Numeric         5       2
   10  MP           Numeric         4
   11  HEATFUSION   Numeric         6       3
   12  BP           Numeric         5
   13  HEATVAPOR    Numeric         6       2
   14  GROUP        Numeric         2
   15  PERIOD       Numeric         2
   16  NATURE       Character       4
```

Elemname = Element name
Elemsym = Element symbol
Atnum = Atomic number
Atwt = Atomic weight
Ionpot = Ionization potential (KCal/mol)
Eneg = Electronegativity
Rad = radii (picometer)
Atvol = Atomic Volume (ml/mol)
Density = Density (gm/ml)
MP = Melting Point (celsius)
HeatFusion = Heat of Fusion (Kcal/mol)
BP = Boiling Point (celsius)
Heatvapor = Heat of Vaporization (Kcal/mol)
Group = Group in Periodic Table
Period = Period in Periodic Table
Nature = M (Metal); NM (Non-Metal);
B (Characteristic of Both)

Table 2
Alphabetical Listing of Database

Record#	ELEMNAME	ELEMSYM	ATNUM	ATWT	IONPOT	ENEG	RAD	ATVOL	DENSITY	MP
1	ALUMINUM	AL	13	27.0	138	1.50	143	10.00	2.70	660
2	ANTIMONY	SB	51	121.8	199	1.90	159	18.20	6.00	631
3	ARGON	AR	18	40.0	363	0.00	98	24.20	1.40	-189
4	ARSENIC	AS	33	74.9	231	2.00	139	13.10	5.70	817
5	BERYLIUM	BE	4	9.0	215	1.50	112	5.00	1.80	1283
6	BORON	B	5	10.8	192	2.00	98	4.30	2.50	2027
7	BROMINE	BR	35	79.9	273	2.80	114	23.50	3.12	-7
8	CADMIUM	CD	48	112.4	207	1.70	154	13.10	8.60	3210
9	CALCIUM	CA	20	40.0	141	1.00	197	25.90	1.55	850
10	CARBON	C	6	12.0	260	2.50	91	5.30	2.26	3550
11	CHLORINE	CL	17	35.5	300	3.00	99	18.70	1.56	-101
12	CHROMIUM	CR	24	52.0	156	1.60	130	7.30	7.10	1900
13	COBALT	CO	27	58.9	181	1.90	125	6.60	8.90	1495
14	COPPER	CU	29	63.6	178	1.90	128	7.10	8.92	1083
15	FLUORINE	F	9	19.0	402	4.00	72	17.10	1.11	-220
16	GALLIUM	GA	31	69.7	138	1.60	141	11.80	5.91	30
17	GERMANIUM	GE	32	72.6	187	1.80	137	13.50	5.36	960
18	HELIUM	HE	2	4.0	567	0.00	93	31.80	0.13	-270
19	HYDROGEN	H	1	1.0	313	2.10	32	14.10	0.07	-259
20	INDIUM	IN	49	114.8	133	1.70	166	15.70	7.30	156
21	IODINE	I	53	126.9	241	2.50	133	25.70	4.93	114
22	IRON	FE	26	55.9	182	1.80	126	7.10	7.86	1539
23	KRYPTON	KR	36	83.8	323	0.00	112	32.20	2.60	-157
24	LITHIUM	LI	3	6.9	124	1.00	155	13.10	0.53	181
25	MAGNESIUM	MG	12	24.3	176	1.20	160	14.00	1.74	650
26	MANGANESE	MN	25	54.9	171	1.50	135	7.60	7.20	1244
27	MOLYBDENUM	MO	42	95.9	166	1.80	139	9.40	10.20	2610
28	NEON	NE	10	20.2	497	0.00	71	16.80	1.20	-249
29	NICKEL	NI	28	58.7	176	1.90	124	6.60	8.90	1455
30	NIOBIUM	NB	41	92.9	156	1.60	146	10.80	8.40	2457
31	NITROGEN	N	7	14.0	336	3.00	92	17.30	0.81	-210
32	OXYGEN	O	8	16.0	314	3.50	73	14.00	1.14	-218
33	PALLADIUM	PD	46	106.4	192	2.20	137	8.90	12.00	1550
34	PHOSPHORUS	P	15	31.0	254	2.10	128	17.00	1.82	44
35	POTASSIUM	K	19	39.1	100	0.80	235	45.30	0.86	63
36	RHODIUM	RH	45	102.9	178	2.20	134	8.20	12.50	1966
37	RUBIDIUM	RB	37	85.5	96	0.80	248	55.90	1.53	39
38	RUTHENIUM	RU	44	101.1	173	2.20	134	8.30	12.20	2427
39	SCANDIUM	SC	21	45.0	151	1.30	162	18.00	2.50	1423
40	SELENIUM	SE	34	79.0	225	2.40	140	16.50	4.70	217
41	SILICON	SI	14	28.0	188	1.80	132	11.70	2.40	1423
42	SILVER	AG	47	107.9	175	1.90	144	10.30	10.50	9610
43	SODIUM	NA	11	23.0	119	0.90	190	23.70	0.97	98
44	STRONTIUM	SR	38	87.6	131	1.00	215	33.70	2.60	770
45	SULFUR	S	16	32.0	239	2.50	127	15.50	2.07	119
46	TECHNETIUM	TC	43	99.0	167	1.90	136	8.85	11.50	2127
47	TELLURIUM	TE	52	127.6	208	2.10	160	20.40	6.10	450
48	TIN	SN	50	118.7	169	1.80	162	16.20	6.00	2320
49	TITANIUM	TI	22	47.9	158	1.50	147	10.60	4.50	1677
50	VANADIUM	V	23	50.9	156	1.60	134	8.50	5.96	1917
51	XENON	XE	54	131.0	280	0.00	131	42.90	3.06	-112
52	YTTRIUM	Y	39	88.9	152	1.20	178	16.20	5.51	1500
53	ZINC	ZN	30	65.4	216	1.60	138	9.20	7.14	4200
54	ZIRCONIUM	ZR	40	91.2	160	1.40	160	14.30	6.40	1852

Table 3
Database Sorted according to Atomic Number

Record#	ELEMNAME	ELEMSYM	ATNUM	ATWT	IONPOT	ENEG	RAD	ATVOL	DENSITY	MP
1	HYDROGEN	H	1	1.0	313	2.10	32	14.10	0.07	-259
2	HELIUM	HE	2	4.0	567	0.00	93	31.80	0.13	-270
3	LITHIUM	LI	3	6.9	124	1.00	155	13.10	0.53	181
4	BERYLIUM	BE	4	9.0	215	1.50	112	5.00	1.80	1283
5	BORON	B	5	10.8	192	2.00	98	4.30	2.50	2027
6	CARBON	C	6	12.0	260	2.50	91	5.30	2.26	3550
7	NITROGEN	N	7	14.0	336	3.00	92	17.30	0.81	-210
8	OXYGEN	O	8	16.0	314	3.50	73	14.00	1.14	-218
9	FLUORINE	F	9	19.0	402	4.00	72	17.10	1.11	-220
10	NEON	NE	10	20.2	497	0.00	71	16.80	1.20	-249
11	SODIUM	NA	11	23.0	119	0.90	190	23.70	0.97	98
12	MAGNESIUM	MG	12	24.3	176	1.20	160	14.00	1.74	650
13	ALUMINUM	AL	13	27.0	138	1.50	143	10.00	2.70	660
14	SILICON	SI	14	28.0	188	1.80	132	11.70	2.40	1423
15	PHOSPHORUS	P	15	31.0	254	2.10	128	17.00	1.82	44
16	SULFUR	S	16	32.0	239	2.50	127	15.50	2.07	119
17	CHLORINE	CL	17	35.5	300	3.00	99	18.70	1.56	-101
18	ARGON	AR	18	40.0	363	0.00	98	24.20	1.40	-189
19	POTASSIUM	K	19	39.1	100	0.80	235	45.30	0.86	63
20	CALCIUM	CA	20	40.0	141	1.00	197	25.90	1.55	850
21	SCANDIUM	SC	21	45.0	151	1.30	162	18.00	2.50	1423
22	TITANIUM	TI	22	47.9	158	1.50	147	10.60	4.50	1677
23	VANADIUM	V	23	50.9	156	1.60	134	8.50	5.96	1917
24	CHROMIUM	CR	24	52.0	156	1.60	130	7.30	7.10	1900
25	MANGANESE	MN	25	54.9	171	1.50	135	7.60	7.20	1244
26	IRON	FE	26	55.9	182	1.80	126	7.10	7.86	1539
27	COBALT	CO	27	58.9	181	1.90	125	6.60	8.90	1495
28	NICKEL	NI	28	58.7	176	1.90	124	6.60	8.90	1455
29	COPPER	CU	29	63.6	178	1.90	128	7.10	8.92	1083
30	ZINC	ZN	30	65.4	216	1.60	138	9.20	7.14	4200
31	GALLIUM	GA	31	69.7	138	1.60	141	11.80	5.91	30
32	GERMANIUM	GE	32	72.6	187	1.80	137	13.50	5.36	960
33	ARSENIC	AS	33	74.9	231	2.00	139	13.10	5.70	817
34	SELENIUM	SE	34	79.0	225	2.40	140	16.50	4.70	217
35	BROMINE	BR	35	79.9	273	2.80	114	23.50	3.12	-7
36	KRYPTON	KR	36	83.8	323	0.00	112	32.20	2.60	-157
37	RUBIDIUM	RB	37	85.5	96	0.80	248	55.90	1.53	39
38	STRONTIUM	SR	38	87.6	131	1.00	215	33.70	2.60	770
39	YTTRIUM	Y	39	88.9	152	1.20	178	16.20	5.51	1500
40	ZIRCONIUM	ZR	40	91.2	160	1.40	160	14.30	6.40	1852
41	NIOBIUM	NB	41	92.9	156	1.60	146	10.80	8.40	2487
42	MOLYBDENUM	MO	42	95.9	166	1.80	139	9.40	10.20	2610
43	TECHNETIUM	TC	43	99.0	167	1.90	136	8.85	11.50	2127
44	RUTHENIUM	RU	44	101.1	173	2.20	134	8.30	12.20	2427
45	RHODIUM	RH	45	102.9	178	2.20	134	8.20	12.50	1966
46	PALLADIUM	PD	46	106.4	192	2.20	137	8.90	12.00	1550
47	SILVER	AG	47	107.9	175	1.90	144	10.30	10.50	9610
48	CADMIUM	CD	48	112.4	207	1.70	154	13.10	8.60	3210
49	INDIUM	IN	49	114.8	133	1.70	166	15.70	7.30	156
50	TIN	SN	50	118.7	169	1.80	162	16.20	6.00	2320
51	ANTIMONY	SB	51	121.8	199	1.90	159	18.20	6.00	631
52	TELLURIUM	TE	52	127.6	208	2.10	160	20.40	6.10	450
53	IODINE	I	53	126.9	241	2.50	133	25.70	4.93	114
54	XENON	XE	54	131.0	280	0.00	131	42.90	3.06	-112

Table 4(a)
Listing of Elements According to a Group
Group 1 Elements

```
Record#  ELEMNAME      ELEMSYM ATNUM  ATWT IONPOT ENEG    RAD ATVOL DENSITY    MP
      3  LITHIUM       LI          3   6.9    124 1.00    155 13.10    0.53   181
     11  SODIUM        NA         11  23.0    119 0.90    190 23.70    0.97    98
     19  POTASSIUM     K          19  39.1    100 0.80    235 45.30    0.86    63
     37  RUBIDIUM      RB         37  85.5     96 0.80    248 55.90    1.53    39
```

```
Record#  ELEMNAME      ELEMSYM  HEATFUSION     BP HEATVAPOR GROUP PERIOD NATURE
      3  LITHIUM       LI            0.720   1331     32.19     1      2 M
     11  SODIUM        NA            0.620    890     21.28     1      3 M
     19  POTASSIUM     K             0.550    766     18.53     1      4 M
     37  RUBIDIUM      RB            0.520    701     16.54     1      5 M
```

Table 5(a)
Listing of Third Period Elements Having Some Metallic Properties

```
Record#  ELEMNAME    ELEMSYM ATNUM  ATWT IONPOT ENEG   RAD ATVOL DENSITY   MP
     11  SODIUM      NA         11  23.0    119 0.90   190 23.70    0.97   98
     12  MAGNESIUM   MG         12  24.3    176 1.20   160 14.00    1.74  650
     13  ALUMINUM    AL         13  27.0    138 1.50   143 10.00    2.70  660
     14  SILICON     SI         14  28.0    188 1.80   132 11.70    2.40 1423


Record#  ELEMNAME    ELEMSYM  HEATFUSION    BP HEATVAPOR GROUP PERIOD NATURE
     11  SODIUM      NA            0.620   890     21.28     1      3 M
     12  MAGNESIUM   MG            2.140  1120     30.75     2      3 M
     13  ALUMINUM    AL            2.550  2447     70.20    13      3 M
     14  SILICON     SI           11.100  2680    105.00    14      3 B
```

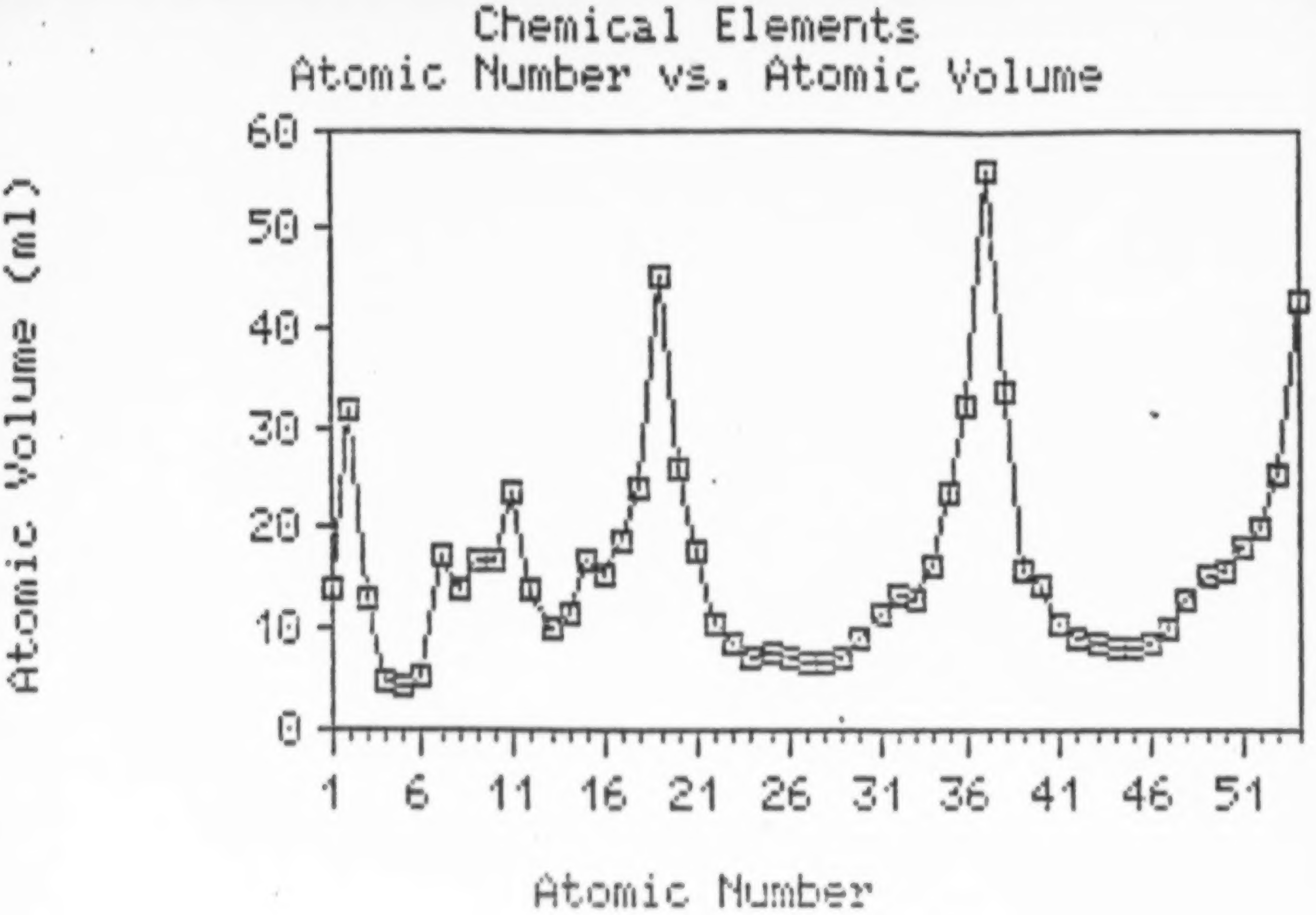


Figure 1
Atomic Number vs. Atomic Volume

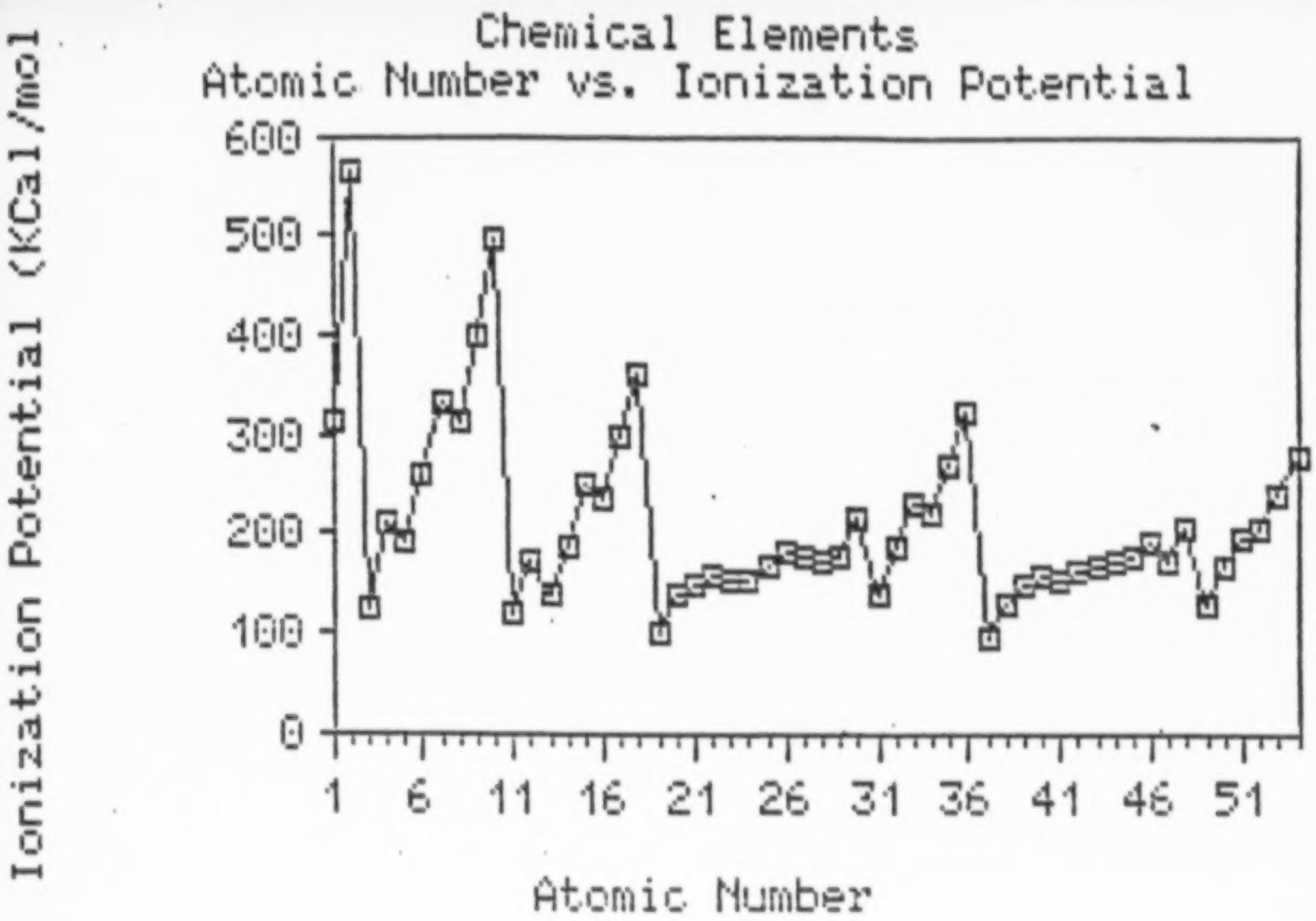


Figure 2
Atomic Number vs. Ionization Potential

The CURRICULUM OF CONCERN

IS YOUR LOGO AN ENDANGERED SPECIES?

MONTGOMERY TOWNSHIP SCHOOLS

SKILLMAN, NJ 08558

IS YOUR LOGO AN ENDANGERED SPECIES?

INTRODUCTION

Let's begin with logos. Alligators on knit shirts. Dolphins on swim suits. American eagles on a parkas. Foxes, cougars or wildcats on cars. Golden bears on sweaters. Buffalos on . . . All desirable labels. All fascinating animals. All in danger of extinction.

At Montgomery, we want our students to be as concerned about others as they are about themselves. About the environment too. Because caring and concern is what is needed if we are going to keep real live animals behind our logos.

Companies have rocks, mountains, trees, rivers, canyons, waves and flowers as logos. Because they mean something. They convey something. They link us to something. Are they important? We say "yes" but live "no."

CURRICULUM OF CONCERN

Montgomery's **Curriculum of Concern** is out to change all that. We're beginning small, with grass roots in our own back yard. But we are beginning, with good ideas, workshops, events, projects, care days, units and activities.

We're bold enough to believe that we can overcome selfishness, apathy and shortsightedness with cooperation, empathy and a community perspective. The ideas aren't new. They're as old as your "civics" course or "out door" education or the concept of "interdependence." What's new is the urgency of the climate we live in, the quality of the air we breathe, the scarcity of the resources we draw on and the selfish materialism we see displayed all around us.

HYPERCARD PRESENTATION

The pages that follow are a printout of our **Macintosh HyperCard Stack** which was the centerpiece of our presentation at the TLC-IV Conference in Washington, DC on February 3-5, 1989. We offer it as *an example of the latest computer technology* that educators can use to communicate S/T/S concerns to various audiences, including their students.

Each card that follows represents one image on the screen of the Macintosh SE. What cannot be shown in linear and static print is the interactive nature of the presentation, the integrated movement of the images on the screen, the coordinated sound emanating from the computer and the wrapt attention of the participants. This can only be experienced on the Macintosh.

For instance, on pages one and two, the eight "logo" cards appear progressively before the user's eyes as soon as he/she clicks to the first card of that sequence. On page two, the eagle disappears from the cross hairs of the gun sight with a sound intended to remind one of a gunshot. In short, anytime a developing sequence is seen on the following pages, the reader can imagine them occuring automatically on the screen "in animation."

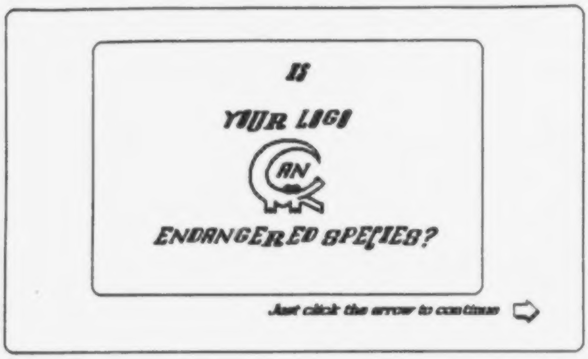
On the bottom left hand corner of page six, the reader will find an example of a card that invites participant interaction. Not only can the operators of the "mouse" select what they might want to "learn more about," but also
they can add their own ideas to the **Curriculum of Concern,** via the scrolling screen on card four of page seven. In this way, they become an active contributor to and developer of the program, instead of just being a passive observer and receiver of information.

MORE INFORMATION

If you would like to receive more information about our **Curriculum of Concern,** please communicate with us at the address below. If you would like a copy of our HyperCard Stack for use on your Macintosh, just send us a 3.5" formatted Mac disk with a self-addressed, stamped envelope and we'll send you a copy.

Dave Cochran, Supervisor of Math/Science/Technology
Larry Ondrejack, Supervisor of Humanities and Technology
Montgomery Township Schools
Skillman, New Jersey, 08558
201-874-4600 x277

IS YOUR LOGO AN ENDANGERED SPECIES?



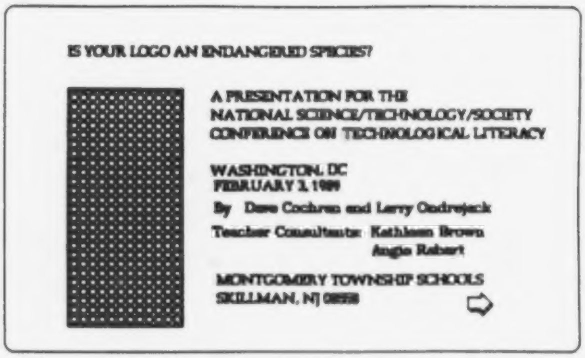
IS

YOUR LOGO

AN

ENDANGERED SPECIES?

Just click the arrow to continue ⇨



IS YOUR LOGO AN ENDANGERED SPECIES?

A PRESENTATION FOR THE
NATIONAL SCIENCE/TECHNOLOGY/SOCIETY
CONFERENCE ON TECHNOLOGICAL LITERACY

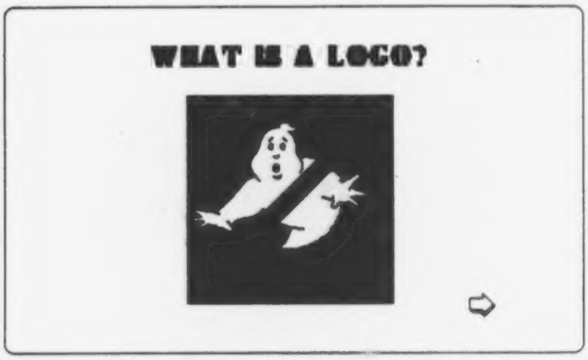
WASHINGTON, DC
FEBRUARY 3, 1989

By Dave Cochran and Larry Ondrejack

Teacher Consultants: Kathleen Brown
Angie Robert

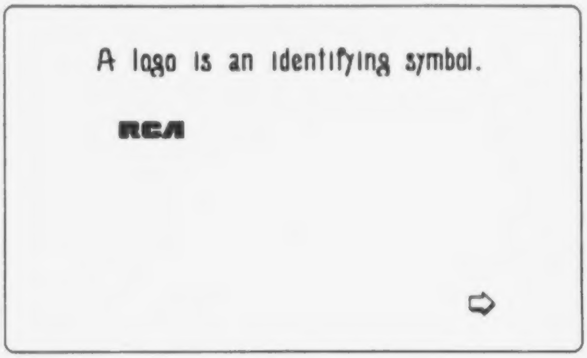
MONTGOMERY TOWNSHIP SCHOOLS
SKILLMAN, NJ 08558

⇨



WHAT IS A LOGO?

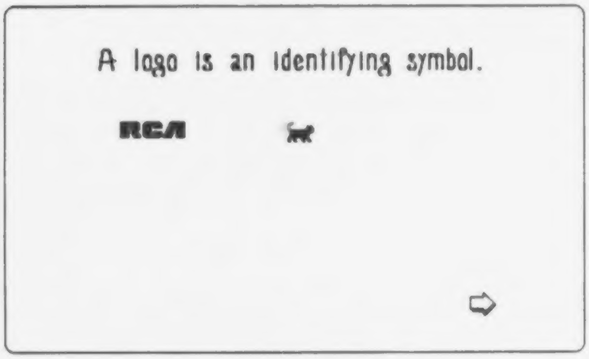
⇨



A logo is an identifying symbol.

RCA

⇨



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RCA

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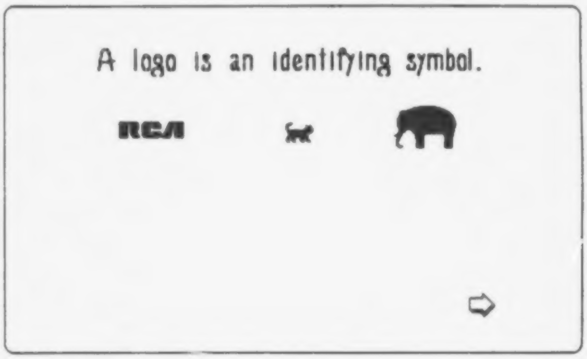

A logo is an identifying symbol.

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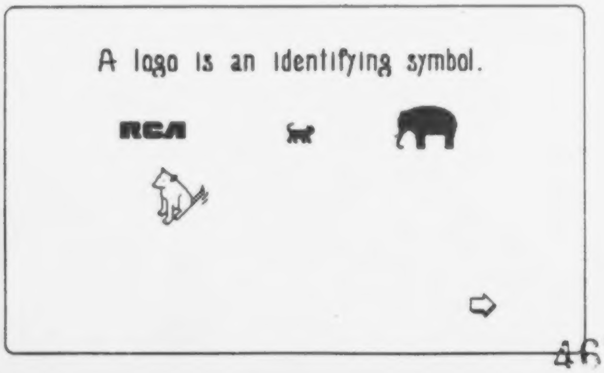

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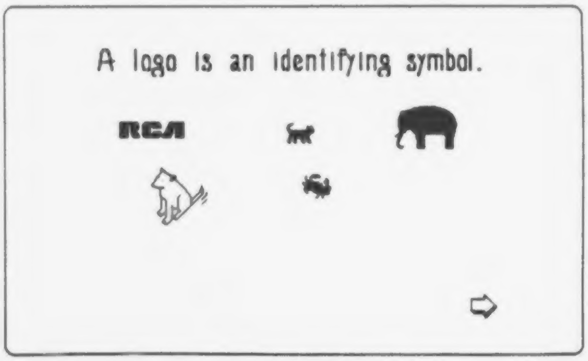

A logo is an identifying symbol.

RCA

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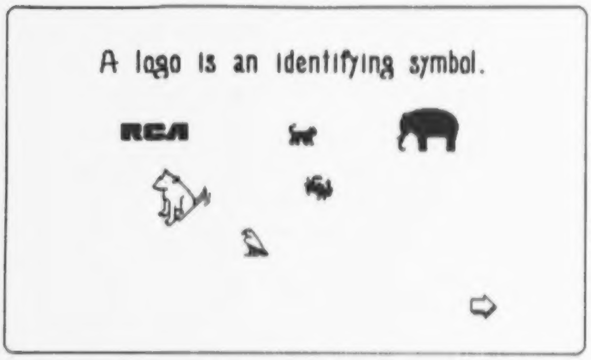
IS YOUR LOGO AN ENDANGERED SPECIES?



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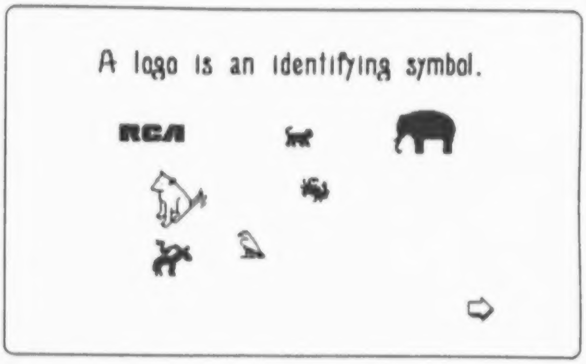

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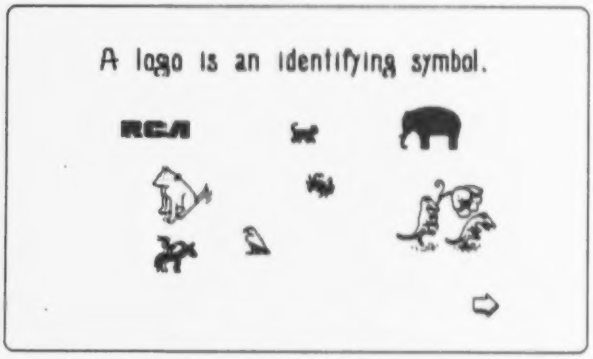

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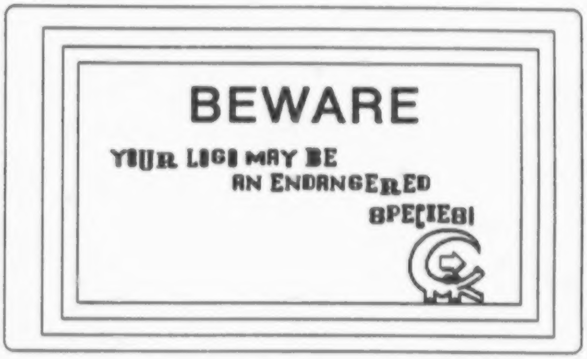
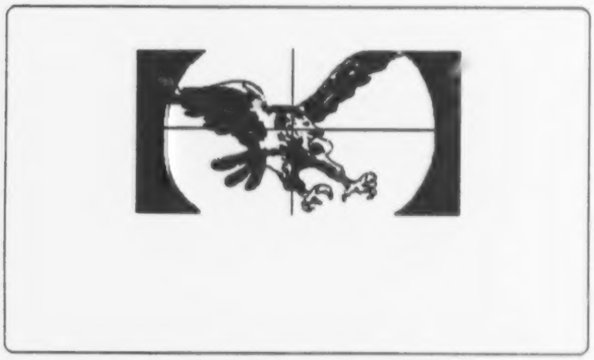
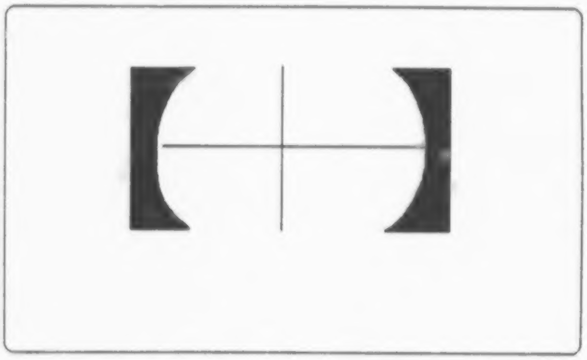
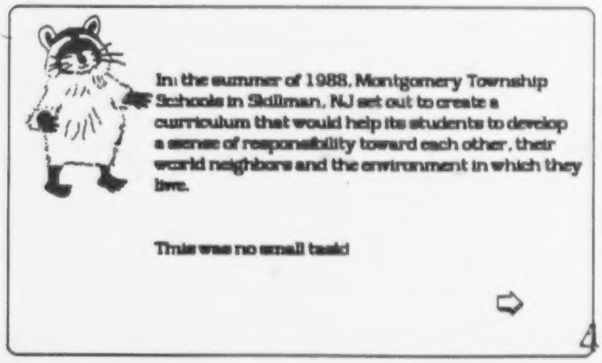


BEWARE

YOUR LOGO MAY BE
AN ENDANGERED
SPECIES!

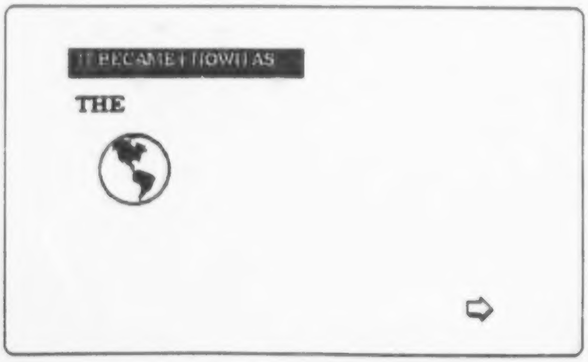






In the summer of 1988, Montgomery Township Schools in Skillman, NJ set out to create a curriculum that would help its students to develop a sense of responsibility toward each other, their world neighbors and the environment in which they live.

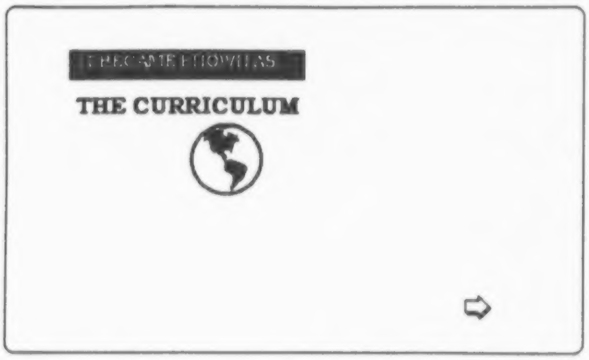
This was no small task!



IT BECAME KNOWN AS

THE

IS YOUR LOGO AN ENDANGERED SPECIES?


IT BECAME KNOWN AS

THE CURRICULUM

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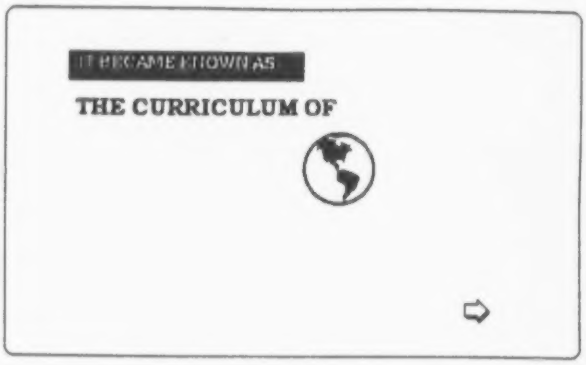
IT BECAME KNOWN AS

THE CURRICULUM OF

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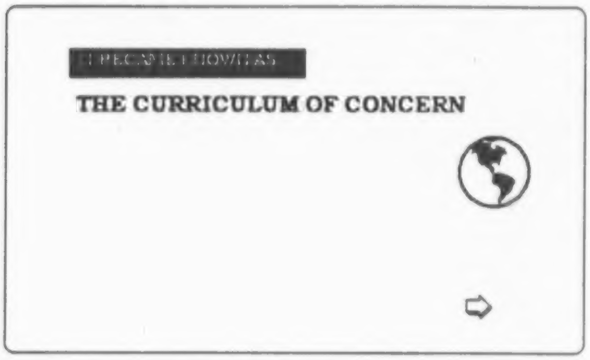
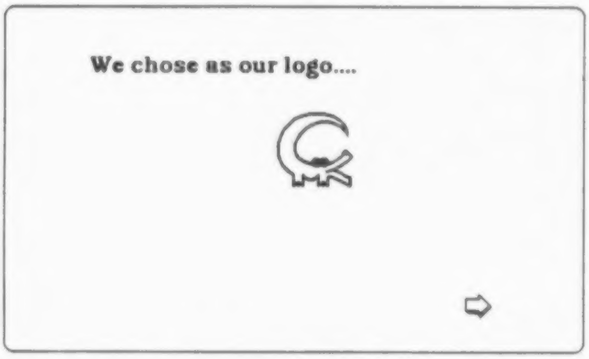

IT BECAME KNOWN AS

THE CURRICULUM OF CONCERN

⇨

We chose as our logo....

⇨


We chose as our logo....

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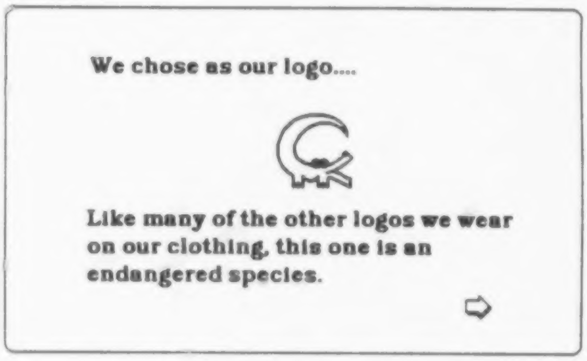
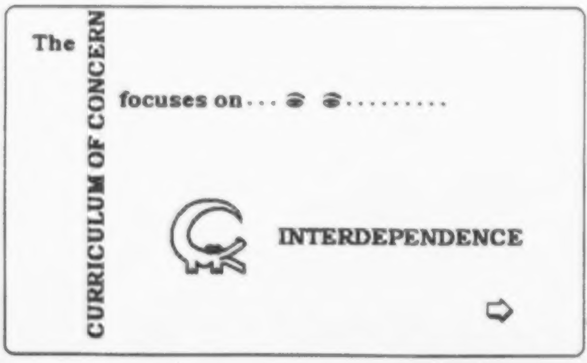

We chose as our logo....

Like many of the other logos we wear on our clothing, this one is an endangered species.

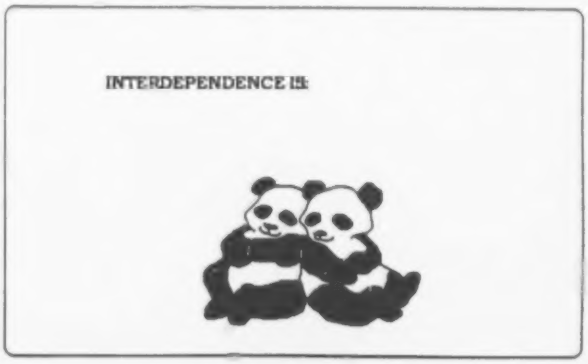
⇨


The CURRICULUM OF CONCERN

focuses on . . . .

INTERDEPENDENCE

⇨


INTERDEPENDENCE IS:

IS YOUR LOGO AN ENDANGERED SPECIES?

INTERDEPENDENCE IS:

THE MUTUAL RELIANCE OF TWO OR MORE PEOPLE, ANIMALS OR ENVIRONMENTAL ELEMENTS ON EACH OTHER.

⇨

INTERDEPENDENCE
is the opposite of

NIMBY
Not In My Back Yard

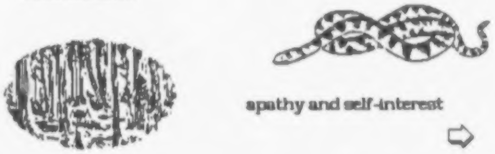
NIMBY is making decisions based on self-interest without regard for the needs of others.

⇨

PROBLEMS THREATEN
OUR HUMAN AND PHYSICAL ENVIRONMENT

deforestation

pollution



apathy and self-interest

⇨

TOGETHER WE HAVE CREATED THE PROBLEMS.

TOGETHER is the ONLY way we can Solve problems.

⇨

COOPERATION

is the key

to achieving our goals and overcoming NIMBY!

⇨

We CAN teach students to understand and appreciate each other and our world neighbors.

⇨

We CAN teach students to understand and appreciate each other and our world neighbors.

We CAN help them to be less self-centered and more empathetic.

⇨

EMPATHY

IS

SEEING THROUGH ANOTHER'S EYES

WALKING IN ANOTHER'S SHOES

AND

CARING.

⇨

IS YOUR LOGO AN ENDANGERED SPECIES?

THE CURRICULUM OF CONCERN

CARING

THE CURRICULUM OF CONCERN

CARING
FOR EACH OTHER

THE CURRICULUM OF CONCERN

CARING

THE CURRICULUM OF CONCERN

CARING
FOR THE ENVIRONMENT

⇨

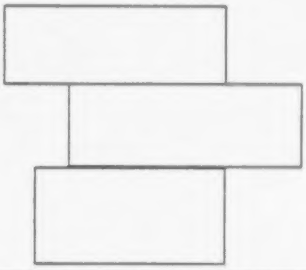
OUR CURRICULUM OF CONCERN

IS BECOMING

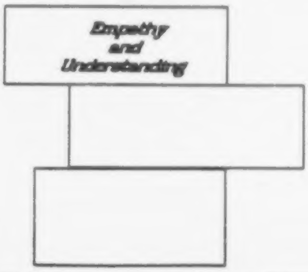
A CURRICULUM OF COMMITMENT

⇨

A COMMITMENT TO BUILDING

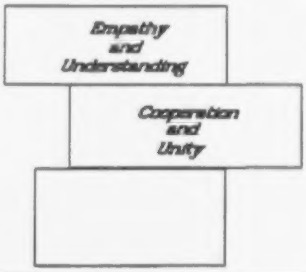


A COMMITMENT TO BUILDING



Empathy
and
Understanding

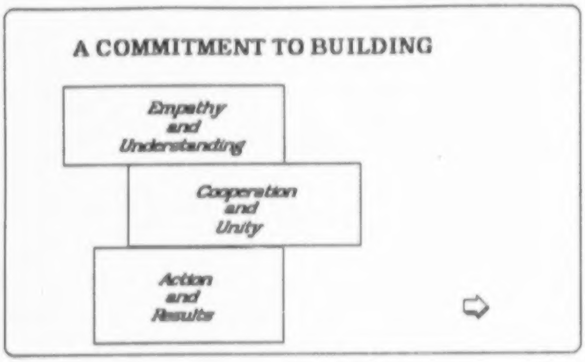
A COMMITMENT TO BUILDING



Empathy
and
Understanding

Cooperation
and
Unity

IS YOUR LOGO AN ENDANGERED SPECIES?

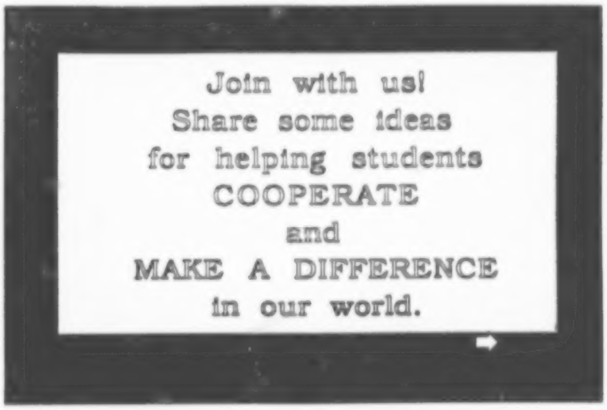


A COMMITMENT TO BUILDING

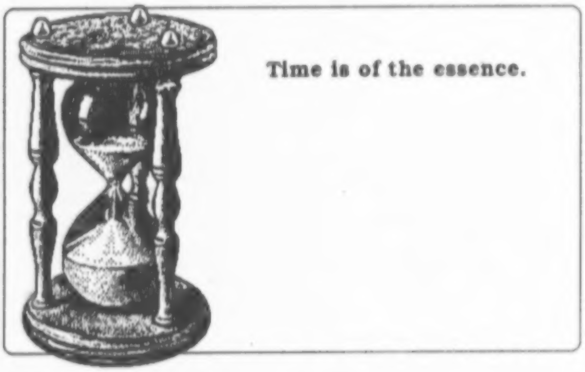
Empathy and Understanding

Cooperation and Unity

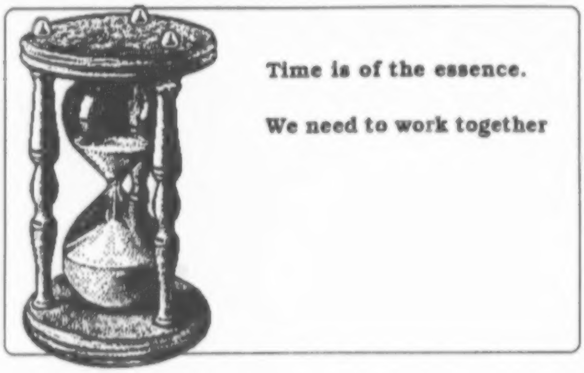
Action and Results



Join with us!
Share some ideas
for helping students
COOPERATE
and
MAKE A DIFFERENCE
in our world.

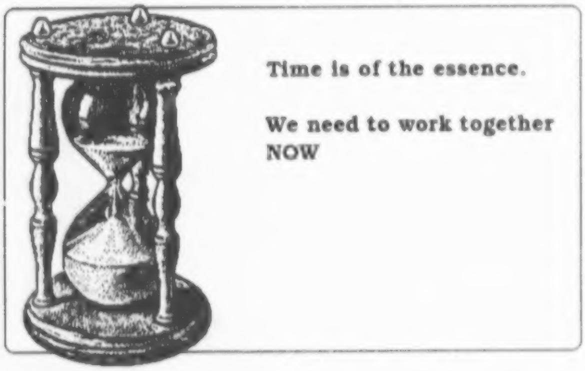


Time is of the essence.



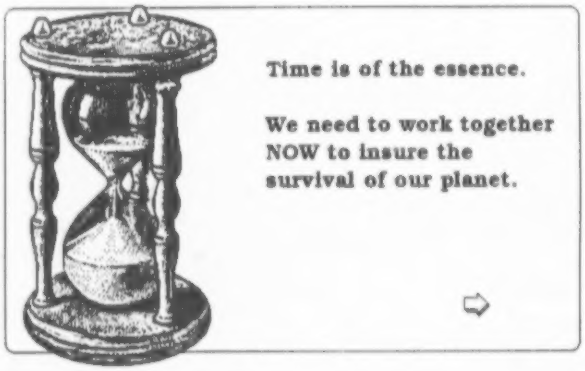
Time is of the essence.

We need to work together



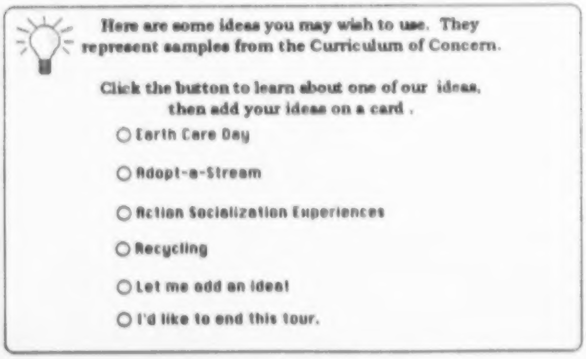
Time is of the essence.

We need to work together NOW



Time is of the essence.

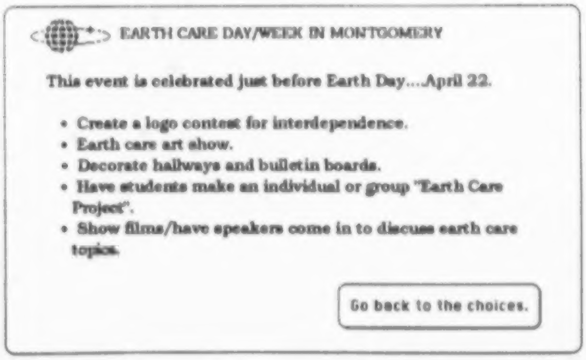
We need to work together NOW to insure the survival of our planet.



Here are some ideas you may wish to use. They represent samples from the Curriculum of Concern.

Click the button to learn about one of our ideas, then add your ideas on a card .

○ Earth Care Day
○ Adopt-a-Stream
○ Action Socialization Experiences
○ Recycling
○ Let me add an idea!
○ I'd like to end this tour.



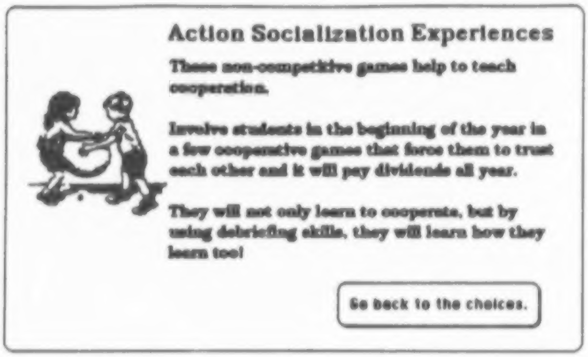
EARTH CARE DAY/WEEK IN MONTGOMERY

This event is celebrated just before Earth Day....April 22.

- **Create a logo contest for interdependence.**
- **Earth care art show.**
- **Decorate hallways and bulletin boards.**
- **Have students make an individual or group "Earth Care Project".**
- **Show films/have speakers come in to discuss earth care topics.**

Go back to the choices.

IS YOUR LOGO AN ENDANGERED SPECIES?

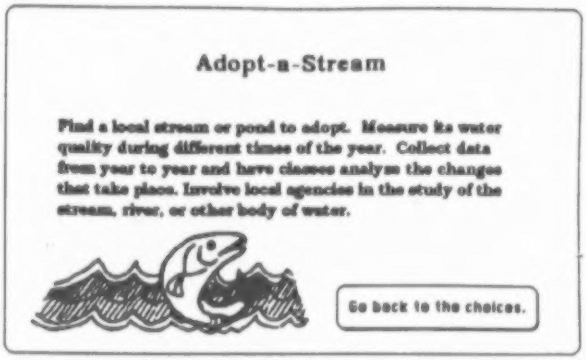


Action Socialization Experiences

These non-competitive games help to teach cooperation.

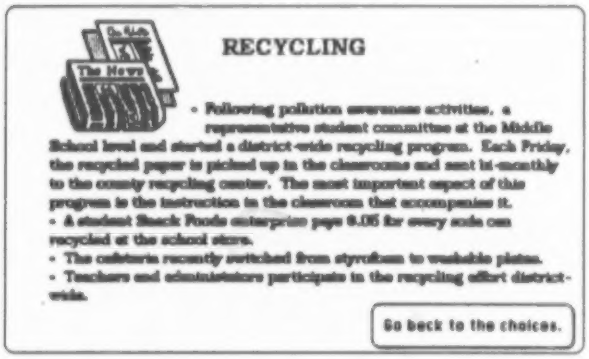
Involve students in the beginning of the year in a few cooperative games that force them to trust each other and it will pay dividends all year.

They will not only learn to cooperate, but by using debriefing skills, they will learn how they learn too!



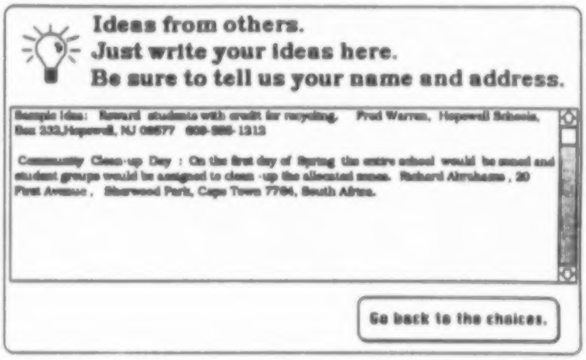
Adopt-a-Stream

Find a local stream or pond to adopt. Measure its water quality during different times of the year. Collect data from year to year and have classes analyze the changes that take place. Involve local agencies in the study of the stream, river, or other body of water.



RECYCLING

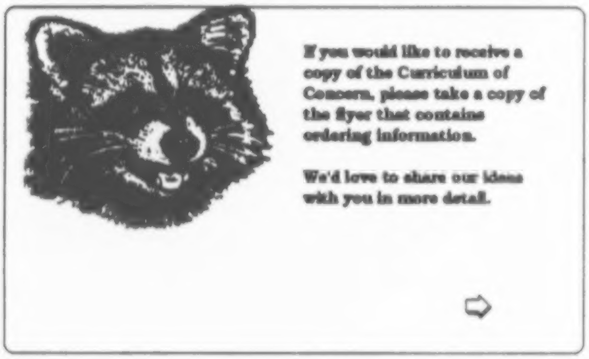
- Following pollution awareness activities, a representative student committee at the Middle School level and started a district-wide recycling program. Each Friday, the recycled paper is picked up in the classrooms and sent bi-monthly to the county recycling center. The most important aspect of this program is the instruction in the classroom that accompanies it.
- A student Snack Foods enterprise pays $.05 for every soda can recycled at the school store.
- The cafeteria recently switched from styrofoam to washable plates.
- Teachers and administrators participate in the recycling effort district-wide.



Ideas from others.
Just write your ideas here.
Be sure to tell us your name and address.

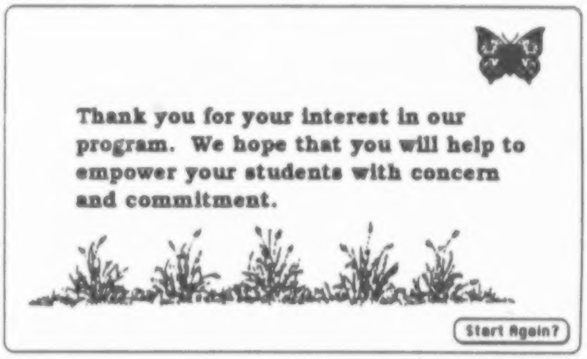
Sample Idea: Reward students with credit for recycling. Fred Warren, Hopewell Schools, Box 232,Hopewell, NJ 08577 609-555-1313

Community Clean-up Day : On the first day of Spring the entire school would be zoned and student groups would be assigned to clean -up the allocated zones. Richard Abrahams , 20 First Avenue , Sherwood Park, Cape Town 7764, South Africa.



If you would like to receive a copy of the Curriculum of Concern, please take a copy of the flyer that contains ordering information.

We'd love to share our ideas with you in more detail.



Thank you for your interest in our program. We hope that you will help to empower your students with concern and commitment.

Preparing People with Information Technologies for Work and the Workplace

Theme -- Technology, Industry and Work:
Employment in America

A paper for the Fourth National Technological Literacy Conference

February 3-5, 1989

Marriott Crystal Gateway

Washington, DC

Gene L. Roth, Coordinator, Office for Vocational, Technical and Career Education, Northern Illinois University, DeKalb, Illinois, 60115; 815/753-1306.

Dennis D. Gooler, Professor, Leadership and Educational Policy Studies, Northern Illinois University, DeKalb, Illinois, 60115; 815/753-0774.

Abstract

Throughout history people have struggled with the meaning and role of work in their lives. It is common to hear middle-aged people ask the question, "I wonder what I should be when I grow up?" While individuals wrestle with their own career development, others debate the methods and processes for preparing masses of people for work in a rapidly changing environment. Creating a technically competent workforce is closely entwined with a country's economic development and global competitiveness.

The instructional tools that may be used to prepare people for work are many, and much more powerful as aids to learning than ever before. As an example, computer based training now accounts for one-third of the corporate training budget. Technologies are often the driving force behind changes in the character of the workplace, yet some of those same technologies hold the key to preparing people to function in new workplaces.

This paper contains a summary of work by the authors regarding potential uses of emerging information technologies to enhance the preparation of people to function in changing workplace environments. Three topics are addressed: increased attention to training in business and industry, efforts in the state of Illinois to revitalize employment programs in the public school education, and the roles of information technologies in preparing people for work.

Preparing People with Information Technologies for Work and the Workplace

Introduction

> Always you have been told that work is a curse and labour a misfortune.
>
> But I say to you that when you work you fulfill a part of earth's furthest dream, assigned to you when that dream was born,
>
> And in keeping yourself with labour you are in truth loving life,
>
> And to love life through labour is to be intimate with life's inmost secret. (Gibran, 1923, pp. 25-26)

The preceding words flowed from the heavy heart of Almustafa, as he prepared to leave the city of Orphalese and board the ship that would take him back to the isle of his birth. He spoke his visionary truths to the people of the city, gathered in remorse at the painful thought of his departure. Almustafa was the beloved lead character of Kahlil Gibran's masterpiece, The Prophet, a book that has been translated into more than twenty languages and has sold millions of copies in the American version alone.

The poignant passage by Almustafa highlights the inner struggles about the role and status of work that have confronted citizens of many civilizations throughout history. Workers of today are just as uncertain of the meaning of work as the ploughman who requested of Almustafa, "Speak to us of work."

As individuals struggle with the meaning and role of work in their own lives, others debate the methods and processes for preparing masses of people for work in a rapidly changing society. The world is much 'smaller' today than it was when Almustafa awaited the schooner that would carry him home. The work of individuals is closely entwined with economic development and global competitiveness, both in the United States and in most countries throughout the world. Furthermore, the instructional tools now available to assist in preparing people for work are many, and much more powerful as aids to learning than ever before. Technologies are often the driving force behind changes in the character of the workplace, yet some of those same technologies hold the key to preparing people to function in new workplaces.

Business and Industry: Educating a Workforce

American businesses are feeling the squeeze of a very tough and competitive global marketplace. Increasingly confronted by international competition, American businesses and industries need well-trained workers now more than ever, especially those corporations that depend on advanced technologies (Ross, 1988). A recent report by the Massachusetts Institute of Technology's Commission of Industrial Productivity argued that a reason American businesses have lost ground to foreign competition is because American workers have traditionally been viewed as cost factors to be minimized, rather than as evolving human resources that should be educated and motivated (cited in "Short-term Focus," 1988). These sentiments are finally, of necessity, beginning to change.

The American Society for Training and Development (ASTD) reported that training and development is growing in stature and is comparable in complexity and size to public education (1986). Whereas $144 billion was spent on elementary and secondary education, informal and formal training and development in the broad field of human resource development totaled $210 billion per year. The ASTD claims that training, and not formal school-based education, provides most job skills to workers, and that formal education accounts for only 15% variation in lifetime earnings compared to 85% generated by work place training. Other facts presented by the ASTD are of interest:

1. As of 1985, 18 corporations were offering college level degree programs.
2. By the year 2000, 75% of all workers currently employed will need retraining.
3. Employee training by employers is the largest delivery system for adult education.
4. Training provides most skills acquired after age 25 and all skills for two out of three jobs.

New technologies that include computer and interactive video systems are altering the ways that business and industry is coping with this heavy training burden. According to Stuart Krasny, President of SK & A Research, computer based training currently accounts for approximately 30% of the corporate training dollar (cited in Ross, 1988). Quality and efficiency seem to be leading the push toward technology-based training. A 1984 study conducted by IBM showed interactive video to be about three times more effective at teaching than an instructor (cited in Ross, 1988). In addition, many consultants believe that computer based training offers a time saving alternative to instructor-lead courses.

Whereas the private sector is gearing up to reskill America's current workforce for an information age, public schools are confronting the challenge of preparing young people, the new workforce, for working roles in our society. In both cases, technology based education and training may serve increasingly important roles for enhancing the quality and increasing the efficiency of the programs.

Education for Employment: Retreading a Tired Program in Illinois

A few years ago the National Alliance of Business held a conference titled "Youth 2000: Challenge and Opportunity." The focus of the conference concerned the challenges that such factors as new technologies, international competition, fluctuations in consumer preferences and demographic shifts will create among work place needs and work force capabilities. The conference brought forth several factors (cited in Carus, 1988):

- Approximately 1 million high school students drop out each year; that number is expected to increase.
- One out of every four ninth graders will not graduate from high school. This rate is higher for minorities and the poor. Some of our large cities have dropout rates of 50%.
- Approximately one out of eight of all 17 year olds in the United States is functionally illiterate.
- New entrants into the labor market between 1986 and 2000 will feature a growing percentage of Black, hispanic, immigrants and individuals

from single parent or poor families.

- The pregnancy rate for young women is increasing. Nearly half of all black females are pregnant before the age 20. Many young mothers never complete high school and these teen-age pregnancies cost the US government over $16 billion a year in welfare costs.

Although these are national problems, they are in part responsible for the major reform initiative undertaken by Illinois to renovate its vocational education programs.

Since the early 1980s, the state of Illinois has been planning and implementing a reform initiative for programs that prepare individuals for work. During the 1982-83 school year, the Illinois State Board of Education examined the state's education for employment system and concluded that an action plan was needed for a comprehensive education for employment program. This initiative brought together many forces that had previously worked independently in preparing youth and adults for employment. Education for employment in Illinois now embodies the various school experiences that have been created to help people of all ages through the stages of awareness, exploration, orientation, and preparation for employment. The following types of programs comprise education for employment in Illinois ("Education for Employment," 1987):

- The state's vocational programs have two broad purposes, preparation of youth and adults for work or for further education. These vocational programs are only distinguished by the nature and level (not age limits) of the student's preparation for work. Some students may elect to take one or two courses, while others may concentrate on a complete program that will permit them to learn entry level skills.
- The employment and training programs (JTPA) permit economically disadvantaged, unemployed youth and adults to gain entrance into the workforce. Participants of this program may receive remedial education, job training and job placement through local programs. These types of programs help unemployed or underemployed youth and adults who lack basic technical or attitudinal skills.
- The career education program is broader in nature. It helps individuals learn about and prepare for work by focusing on career development needs of individual students.
- The adult education program serves learners who are at least 16 years old who have either not attained a high school diploma or have not achieved an equivalent level of education. Adult education experiences include programs in vocational education settings that help adults receive basic technical and attitudinal skills.

Since 1985, many activities have taken place at the state and local level that have brought together the programs of adult, career employment and training and vocational education. The Illinois Policy and Plan for Education for Employment (1984) guided local education leaders in a process of analyzing labor market information. Each education for employment region formulated a profile of employers in the region, identified the largest and fastest growing occupations in that region, and utilized employer and occupational profiles to identify occupations within the region that had the greatest employment potential.

Local educational leaders also assessed information on populations, student enrollment, census data and unemployment data. These planning data were used by local educators to identify trends that might indicate vocational education program growth and expansion. Accessing and analyzing such data as labor market information helped education for employment planners access external forces that might shape the future of vocational education (Helbling, Roth & Seidman, 1987).

The Illinois Policy and Plan for Education for Employment (1984) also required local planners to examine student interest information. Approximately 160,000 tenth graders were surveyed with a student interest inventory in 1985. The survey provided general data regarding the types of vocational education programs that generated the most interest by sophomore students.

Revitalization of Public School Curriculum

The education for employment initiative has rekindled the spirit and energy of educators who prepare learners for work. Revitalization of education for employment programs has been based on a systematic planning process. This process has been based on an examination of student interest data, labor market information, profiles of existing and potential resources and articulation efforts among secondary and post-secondary institutions.

Paramount in this revitalization process is the work that is being done in curriculum development. Currently, education for employment systems in Illinois are going through a major renovation of curriculum materials. Reshaping vocational education curriculum will be based on worker task lists that had been verified by incumbent workers for specific occupational education programs. The curriculum renovation process in Illinois thus involves workers from the private sector who have substantial input to the content and methods used in vocational education classes.

Quality instructional materials may have a dramatic impact on learning in classrooms. Unfortunately, a lot of instructional materials found in schools do not incorporate research principles of effective curriculum design. If current course materials are rewritten to include fundamental elements such as a clear outline and statements of purpose, systematically structured modules and concrete examples of theoretical concepts, test results show that average educational effectiveness (measured by actual student performance) could be increased by 50-100% (Snyder, 1987). The education for employment curriculum process involves a structured examination of instructional materials.

The Role of Information Technologies in Preparing Learners for Work

Along with the concern for developing quality instructional materials comes the question "how can new information technologies improve the quality, enhance the efficiency and create greater access to education for employment programs in Illinois?" In search of the answer to this question, the Illinois State Board of Education, Department of Adult, Vocational and Technical Education funded a project at Northern Illinois University titled Change, Technology and Vocational Education. The intent of this project is to examine state of the art information technologies, and how they might be applied in education for employment. Technologies such as microcomputers or interactive videodiscs may be used in a variety of ways in education for employment. In addition, there are new forms or combinations of technologies that may have potential for application in education for employment. The NIU project was especially concerned with new integrated instructional technology systems.

One of the products of this project is titled Instructional Technology Systems Applications in Vocational Education: A Notebook of Cases.

Information was collected on several instructional technology systems that appear to have potential applications in vocational education. These technology systems were presented in the form of case studies. The case studies included in the Notebook included: 1) two-way interactive television, 2) a networked computer based laboratory, 3) an integrated information technology system, and 4) an overview of technology and training in the nuclear industry. The following narrative provides a brief capsule of each case study.

Two-way Interactive Television - The TeleSystems Approach

The power and pervasiveness of television as a medium in American society is well recognized. In preparing the project notebook, the authors considered various approaches to the use of television as an instructional medium. An interactive television system from a company called TeleSystems Associates, Inc. of Bloomington, Minnesota, appears to hold a great deal of promise for education for employment programs. These applications seem especially well suited for rural areas that are experiencing diminishing learning opportunities for students, as well as situations where teacher shortages in content areas restrict student access to certain academic disciplines.

The premise behind the TeleSystem approach is to connect schools with a highly interactive television system in a manner that allows a single teacher to teach a course to multiple school districts simultaneously, with the realism of face-to-face contact. Students are able to see and communicate with other students, the teacher is able to see and communicate with students in the other schools, and in some cases students and teachers are able to transmit materials back and forth with a facsimile machine. There appears to be several advantages of this particular form of two-way interactive television. Small, isolated schools may through the system offer low enrollment, low incident classes that otherwise would not be feasible. In addition, students may stay enrolled in their smaller home schools without having to be bussed to other regional schools (Gooler & Roth, in press).

Two-way interactive television appears to have many potential applications for education for employment programs that can serve the educational needs of students as well as increase professional development opportunities for teachers and administrators. The system needs to be tested and evaluated as a method of delivering education for employment programs. Evaluation results should be compared with traditional methods for delivering education for employment so we can examine the positive and negative outcomes of teaching and learning through two-way interactive television systems.

Integrated Learning Systems

The second case study highlighted a type of learning system that is most often referred to as an integrated learning system. Integrated learning systems offer a carefully designed and developed curriculum/instructional program. This type of system goes beyond hardware and software that function as individual units. Integrated learning systems use hardware and software in different ways than have been traditionally used in schools. The case study included in the Change, Technology and Vocational Education project highlights a system developed by Education Systems Corporation (ESC) of San Diego, California.

The hardware components of the ESC learning system include microcomputers, network software, CD-ROM (compact disc, read only memory), 16 color technology, animation, music, digitized human voice and the input devises of a mouse and a keyboard. What makes this system unique is the company's commitment to providing a curriculum rather than a collection of unrelated educational programming or individual pieces of hardware. This integrated learning system contains curriculum content, instructional and assessment strategies, and a method for managing the learning and teaching processes. Another unique perspective of an integrated learning system such as this is that instructional strategies are matched to the content so that the hardware capabilities are used to the best extent possible.

At the time of this writing, the ESC system had been installed in 237 schools in 27 states plus the District of Columbia. The company has conducted many studies of the system in operation in these schools. The system should work for several reasons: 1) curricula have been carefully selected with advise from prominent subject matter specialists; 2) content has been aligned with testing measures and other forms of curriculum mandates; 3) instructional strategies have been carefully designed according to extant theories of teaching and learning; 4) attention has been paid to student motivational factors; 5) materials have been pilot tested and evaluated; 6) hardware and software systems have been selected and designed to be user friendly; 7) instructional management systems have been carefully built into the system; 8) research and evaluation studies have been conducted; and 9) support systems have been carefully developed and provided for schools buying the system.

The Education Systems Corporation package is a good example of what can happen when instructional designers and curriculum specialists work hand in hand to make a technology work for instructional purposes.

A Large Scale Integrated Technology System

The third case study included in the Change, Technology and Vocational Education project is the development and implementation of a large scale integrated technology system. This case study focuses on the Sacramento City Unified Public School District, one of five model technology school efforts funded by the State Department of Education in California. The Sacramento City Model Technology School Project (SCMTS) provides insight into a total information technology system for use in schools.

The Sacramento MTS involves one elementary, one middle and one high school in the Sacramento City Unified School District. The MTS projects are scheduled for a period of five years, funded by the state at approximately $500,000 per year. The technology system envisioned for this project is to be used by learners to achieve certain desired learner outcomes. The fundamental interests undergirding the project are to understand how learners can and do utilize technologies to pursue learning goals, to determine the extent to which learners are successful in achieving established goals or intended outcomes, and to examine the short and long-range consequences of involving technology in the instructional program of the schools. Toward these goals, the SCMTS project intends to develop and implement a range of instructional support activities including training programs, information resource acquisition, development of partnerships between schools and businesses and other activities that will facilitate instructional activities that comprise the focus of the project.

The information technology system for the SCMTS project is composed of modules or collections/packages of technologies, each of which has an identifiable function within the overall design of the system. These modules are expected to be installed at each of the three MTS schools, generally in the form of a classroom. These three model technology classrooms will serve only the SCMTS project. Each of the modules will contain a teacher workstation, student workstations, an information resource library, a development authoring workstation, an administrative workstation, and a home based technology unit. The modules are networked so the components of each module in the system can interact with all other components of the system.

Training in the Nuclear Power Industry

The fourth case study of the project pertains to instructional technology applications in industrial training, in particular the nuclear power industry. This case study describes a number of instructional tools that are used by the nuclear industry to satisfy training needs. The rule of thumb in the nuclear industry, similar to any competitive industry, has been to meet the performance training objective in the most cost effective manner. A number of training tools are highlighted in this case study. A study pack system, video graphics that include CAD/CAM training graphics and video show presentation systems, a computerized exam bank, static and dynamic models, mock ups, computer based training, interactive video discs, particle scope simulation, artificial intelligence and full scope simulation.

Many computer aided training tools are both currently implemented and still evolving within the nuclear power industry. When developed and applied correctly, these tools insure mastery of training objectives in a cost effective, well documented and often self paced manner.

Education for Employment Training and Retraining for a Competitive Workforce

The most powerful resource of the United States--its human resource--must be finely tuned to keep our economy from losing additional ground to foreign competitors. This fine tuning will require collaborative efforts from public education and businesses and industries who share the mutual concern of strengthening our workforce. The productivity of our country is at stake, as is our standard of living and our need to improve it.

Business and industry is faced with the prospect of abandoning practices that have served them well in the past but are no longer valid in today's market (cited in "Short Term Focus," 1988). Many practices of public schools deserve the same scrutiny. Administrators, school board members, parents, teachers and students must recognize education for employment programs as viable conduits for passage from school to work. Education for employment programs can benefit those individuals who want to compete for the growing number of jobs that do not require a baccalaureate degree.

To attract students to these types of programs, we must focus on improving the quality, enhancing the efficiency, and increasing degree of access to education for employment. Information technologies show promise for serving these goals of access, quality and efficiency. Cooperative efforts of instructional designers and content experts are needed to help vocational educators create instructional programming that capitalizes on the strengths of these new technologies. The performances of these instructional technologies should then be evaluated in education for employment settings. Comparisons are needed among vocational education programming that highlight new information technology versus traditional methods of instruction. These types of comparative reviews will give us direction for planning education for employment programs that best meet the learning needs of students.

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INTRODUCTION

CYBERNETICS REVISITED

Over forty years ago, in 1948, Wiener published his Cybernetics: Control and Communication in the Animal and Machine. In the intervening years, this second industrial revolution, as cybernetics is known, has developed toward general theories of Communication and Control within complex systems. Its scientific content has been elaborated by many scholars, notably:

- Work on complex networks of communication has suggested the notion of organization as the prime focus of cybernetics (Warren S. McCulloch, Heinz von Foerster);
- Studies of circular flows of information, mutual causality and the dynamics they imply have associated with theories of control that are entirely neutral and predictive in orientation (Norbert Wiener, Magorah Maruyama);
- Research on decision-making and on information transmissions together with advances in recursive theories of computation have lead cybernetics to describe living organisms as adaptively changing information processors (John von Neuman); or adaptingly changing the environment to suit the individual (D.R. Steg).
- Philosophical analysis have identified cybernetics as the science of models, including those of self-reference (W. Ross Ashby, Anthony Wilden);
- Generalizations from ecology which see man in interaction with his environment of physical, social and information contingencies

have relativised the notion of mind (Gregory Bateson) and that of man as a self-governing being (Karl W. Deutsch).

Each of the above key concepts, organization, control, adaptivity, modeling, self-reference, and self-governing being, can be coalesced within the framework below, a general theory, with empirical substantiation, [1] applicable to all complex social systems. This framework, briefly described in Part I, has been developed since 1962. The empirical studies will be reported on in the second part of this study.

It is helpful to consider cybernetics as the language of communication and systems analysis as the syntax.

Part I

Behavior: Adaptive versus Adapting

ADAPTIVE

Automatic activity of man, animal or machine is an adaptive control system, by its very nature. It is safe to assume that, as with the laws of physics, the laws governing control systems apply equally to animal, man or machine. In the language of the system engineer, this is a closed-loop control system. The control system pattern consists of (1) an input signal that triggers some action, (2) a feedback signal of the result of this action to compare with the input signal, (3) a closing of the loop and a summation of the two signals and (4) effective action to counteract this summating signal. A persistent residuary signal can be made to affect memory which results in "learning". In a control system, work is triggered as a result of an actual error imput. [2] The error is essential to the activity of any control system. These mechanical patterns apply equally to automatic machinery, animal behavior, and man's everyday automatic activity. (Figure I)

ADAPTING

An important deviation from the automatic pattern occurs when the automaticity of a system is eliminated. Non-automatic activity will not necessarily be subjected to the adaptive nature of the control system and trigger its energy to cancel the disturbance.

With the automaticity eliminated the response to a disturbance is chosen after the disturbance has been analyzed as to its source, the energy involved in the disturbance, the possible response and resulting consequences, including analysis and assessment of energy sources and energy balances. In other words, understanding is replacing automatic response. (Figure II)

To recapitulate, an adaptive control system is subject to the effect of the environment on its sensing elements and has no freedom to control the effect of the environment on its sensing elements. It can only adapt the system by using its own energy to satisfy the requirement from the environment conveyed through the sensors.

Opposed to this automaticity is the human ability of adapting an environment by means that extend human reach in a specific fashion, including in the process the use of tools, machines, as well as psychological, socio-political, economics, educational tools and other instruments. Specifically, the human mechanism directs the signal-triggered action with a view to the adaptation of the environment to eliminate the differential between the fed-back signal resulting from the modified environment and the original input signal. The mechanism involved in the latter system or disturbance is subject to the "filter" of intelligence, thus creating an "art image" of the environment to serve as a blueprint for the adapting process. [21, 23, 25]. The system involved in specifically human activity is operable only when an act is triggered to adapt the existing, "given", "objective" environment to an "art" or "dream image".

As defined by Dewey, art is "to select what is significant and to reject by the very same impulse what is irrelevant and thereby compressing and intensifying the significant" [8:208]. We should add to the statement that both the "significant" and the "irrelevant" are dynamic concepts that continuously change position. Because machines have only automatic, adaptive responses, and thus have built-in qualitative aspects, or "significant aspects", "creativity" is impossible.

Education, formal and/or informal, is the phenomenon which initiates a control activity, triggered by the element of relation, association or construction that appears, for example, when an artist produces an image unlike the one achieved by a camera. It also appears in all scientific discovery, as a change from the accepted previous concept. In other words, education centers on the "art" created image and its involvement in control system activity.

Adapting behavior depends on education and not training alone. Training involves learning some specified pattern of behavior, be it prestidigitation or tightrope walking, while education is new concept formation. The result of education is creativity, while the result of training is performance involving skill.

If the adapting control process "filters" disturbances, or input signals, in the closed-loop servo-system which control human action, education is then taking place.

The servo-mechanism of the human control system continuously develops and grows as thinking develops and grows. Inquiry and correlation of experience are tools used in this process of education; they are elements which trigger the controls. As for experience itself, we can no more know what a particular "experience" will do to education than what a "pencil" will write. Experience, of course, is a pre-requisite, just as one needs a pencil or something to write with.

Any realization of something being wrong is a discovery. It contradicts the previously assumed satisfactory order. Anything that has been "logical" up to this point becomes "illogical", becomes "wrong", becomes an "error", and will make room for the elimination of error-for a new logic-for the "ought" instead of the "is." This realization that something is wrong (which initiates the process) is a prerequisite required for new concept formation. There is a difference between man and animal, or man and machine, which is made to simulate man's behavior. The computer essentially accomplishes its function by operating on a multitude of types of problems with techniques for solving them. Thus, a problem fed into the computer in a sense triggers the answer that was originally built into it. But, to reiterate, human problem-solving is a matter of education and growth. It creates or formulates problems and at times their solutions.

While one can decide which behavior one wishes to enhance, it is well to realize that the trend is fairly clear in the area of consumer behavior or in the field of learning, in the acquisition of skills for instance (see part II). While conceivable these behaviors are unique, it is certainly not likely [29]. They have been generalized to social [6] political [7], as well as ethical [23], psychological [18,21] and economic [14,15,16,19, 20, 29] behavior.

If adapting behavior is aimed for, then the following are critical:

- ways of handling variety [3] [1:244]
- access to information, or selectivity of information [1:252]

Beyond deviation-counteracting feedback or negative feedback, there is also the possibility of a deviation-amplifying component, or positive feedback [26, 31].

We have, thus, a model of thinking which contains quality as an essential element and operates pragmatically as a closed self-organizing loop. It accounts in a new way for teleological processes like problem-solving, "planning", and mechanistic behavior. It allows for an infinite variety of awareness-cognition-responsive feedback systems.

PART II

ADAPTING BEHAVIOR OF THE CONSUMER IN ECONOMIC LIFE

At a point of economic affluence in any society, where a large majority of the population is living at a level considered by its culture to be "modest but adequate", [11, 13] and has major discretionary purchasing power in terms of whatever costs are being considered within the parameters of the culture, consumers of goods and services begin to exhibit patterns of "adapting behavior". These patterns are quantifiable and measurable in terms of price elasticity of demand and income elasticity of consumption, both over time and at specific single periods of time, for specific characteristics of both goods and prices. The analysis of consumer behavior which follows is the collaborative work of Schulman and Steg [19, 20, 29].

The data show that consumer demand becomes inelastic as income and education increase, even for discretionary purchases; and that the substitution effect thus becomes a more important part of the change in purchasing patterns than the income effect. The substitution effect causes the buyer to follow a "least-cost" pattern of purchase, whatever the important component of cost may be for the individual - money, time or convenience. Declining elasticity causes a more rigid purchasing pattern on the one hand (I want what I want, when I want it), and on the other hand a more flexible willingness to switch from one good to another (when the two goods have almost identical characteristics) on the basis of price in terms of money, time or convenience. It also shows that the consumer has learned to say "no".

Consumers purchase bundles of "characteristics" [10, 11, 12] and not individual goods and services. Demand loses elasticity for many characteristics with rising income and education (no other variables proving significant). This loss of elasticity and consequent increase in the importance of the least-cost substitution) effect extends to almost all characteristics and costs with the exception of those falling within the self-organized and "adapting" behavior patterns where the human system changes the environment to suit itself.

As economic affluence increases, the effects of inelasticity of demand become evident in all material-reward oriented cultures, no matter what their political, economic or social systems. When a dictatorial society decides not to make desired consumer goods available--the most profitable industry in such a society will be underground, outside-the-law or smuggling oriented.[4]

It is extremely important to relate the Lancastrian concepts of "bundles of characteristics" with declining price elasticity of demand. First of all, just as there are "bundles of characteristics" there are various types of prices. There are money prices, time prices (the amount of hours spent in any transaction), and almost any other type of prices which a consumer is normally willing to pay. What confuses the average non-economically oriented individual is that a price may also be good in itself, as a commodity or characteristic. For example, just as we pay in money, when we borrow money, we pay a price for money. Just as we pay in time, when we use a time-saving device, we are paying a price for time. Just as we may pay in convenience or effort, when we use a particular salesperson in a particular store, we may be paying a price for saving convenience or effort.

It is an economic axiom that although a particular consumer demand for a particular commodity is completely satiable, the totality of all consumer demands for all commodities is insatiable. This same axiom is applicable to characteristics and to prices. At the present stage of American society the desire of people to save money may be much less important than the desire of people to save time. This is particularly true as more women with families enter the labor force. It is even more true of the white collar than the blue collar worker, and the preponderance of our labor force today is white collar workers and has been so for over the past twenty years.

In the U.S. the discretionary income class became a majority after 1964. We now have evidence that the majority of black people have entered the middle class as of 1972. [37]

It is, therefore, incumbent upon the economist in any discussion of adapting behavior to understand clearly the differentiation between money elasticity of demand, time elasticity of demand, and convenience elasticity of demand. These may and do differ by income groups by education and by extent of participation of the family within the labor force. The perfect example of this type of differentiation can be obtained from a new commodity appearing on the market within the past three years which was specifically tailored for the working wife and mother and which has had a phenomenal success in a field where the hope of new demand or increasing elasticity of demand was almost forgotten - food. The introduction of the differentiated meal by Birds-Eye in the form of different combinations of vegetables took the market by storm. It is interesting to note that price-wise, compared to the normal frozen vegetable, the Birds-Eye Hawaiian vegetables, the Birds-Eye Italian vegetables, the Birds-Eye French vegetables, etc. started as being almost double or triple in price. Nevertheless, these vegetables not only sold but sold out.

What was hapening could only be analyzed on the basis of the characteristics which the consumer was purchasing. The consumer's money and time price demand, that is, the consumer's value for money and time per se, was virtually inelastic for a working woman, but the consumer's demand for convenience had almost infinite elasticity and the woman was willing to pay the money price. When the actual nutritional surveys were done of the contents of these packages, plus the amount of time required to prepare both from scratch and from prepared foods, it was found that the time savings approached any place between 40 minutes and 1 hour and 8 minutes in the preparation of these particular combinations. Therefore, the woman purchasing these vegetables and the family using them, was paying for convenience and for time, not for the contents of the package. In figuring that time at the minimal rate for household help of $2.00 per hour, it was figured that the price per portion was something like $.60 less, including the ingredients, than when these particular combinations had to be prepared at home. For the family where both the adults are working the money elasticity is extremely inelastic, time elasticity is very inelastic, but the need for convenience becomes extremely elastic and the greater the amount of convenience given by whatever good it is per portion or item, the higher the price in money and in many cases in time the consumer will be willing to pay.

Today, Birds-Eye is going into the preparation of entire meals in the same fashion: where money price Is high, time price is very low and convenience price is practically near zero. Recipes are given out with every package showing how meals may be prepared in less than five minutes. Since the value of the money as money is much lower than the value of the time and effort saved, the money price charged can be higher. Therefore, simple projections of elasticity of demand on the basis of percentage of income change spent of a particular good, drops in importance. What becomes all important is what price is being paid for what characteristic.

The only price and characteristic in which consumers will have elastic demand in the future, as we become more and more of an upper middle income society (by the year 2020 it has been estimated that approximately less than 7% of our total population will be living in the poverty or near poverty brackets), will be convenience and variety. Demand in total is becoming inelastic in terms of money, inelastic in price of time, but elastic in convenience and effort price and elastic for variety.

Unfortunately that data are not presently available except in isolated cases (such as the food mentioned above) to enable us to do a true characteristic-differential price analysis of elasticity for all goods. However, new phenomena are arising, reported in the financial news, magazines,and in other public media which gave rise to the speculation that as far as income is concerned, the 1971-72 data shows almost total inelasticity for practically every commodity with the exception of human investments and services, [2, 35, 36], included are education, medical care, recreation (both participatory and non-participatory) and travel.

This does not mean that in terms of another kind of price than money, demand will not be elastic. It will, but the difficulty is that we presently do not have the data, although we have the techniques for estimating the particular convenience price elasticity for something other than an item like Birds-Eye Hawaiian vegetables.

RIGIDITY OF DEMAND

Since 1953 we have been observing an economic phenomenon for which there was no apparent explanation. That phenomenon was declining price elasticity of demand as measured by income elasticity of consumption. In other words, an ossification of purchasing pattern was spreading through every income class of America, except the poor. Businesses were going bankrupt without apparent cause in the midst of unprecedented prosperity.

By 1963 when accurate data became availabe [34], it became evident that there had been, over the period, a change in elasticity (the ratio between a difference in expenditure for a particular good and an income change). Elasticity was declining due to increase in income and education. No other variable proved significant. Of the two, education showed the most significant pattern [34, 35, 36].

Demand in general, and demand for goods in particular, has become virtually income inelastic or unitary elastic at the time of the 1972-73 survey. Hence, buying is even more individualized and less influenced by media or groups. It was thought that the general shift in elasticity between 1950 and 1960 would cause a downward shift in general income elasticity of consumption of approximately 5-7% between the sixties and the seventies. In other words, as people become more educated, the pattern of living becomes more rigid, this in turn leads to a decline in elasticity, where living patterns are less influenced by income. As it turned out, the downward shift was even greater [35, 36].

It has always been postulated by economic theorists that mean elasticity of consumption declines for goods as income rises. But this time, the data showed an even greater decline with an increase in education. This was contrary to all predictions and could not be explained on the basis of any previous postulate, (whether Keynesian, Friedman's permanent income hypothesis, the adaptation of the permanent wealth theory; or Duesenberry's previous standard of living hypothesis).

When Steg's paper [21, 22, 23, 24, 25] were "finally digested" by Schulman, it became evident that they were an explicative formula for this economic behavioral phenomenon. The consumer was "learning" and exhibiting an "adapting behavior" cybernetic mechanism. Only a continuous feedback[7] (hence cybernetic), explains the human transactions in today's consumption. Unfortunately, it is not only manufacturers who are unaware of either its existence or meaning.

In the paper on "Communication and Feedback in the Technology of Consumption", [16], Schulman has shown that in a society where discretionary (non-necessity) purchases and consumption are available to the majority of the population, the consumer becomes a "least cost" buyer for necessities, and refuses to follow previously established patterns of authority in purchasing descretionary goods. [14, 16]. In a free or semi-free market, this plays havoc with fashion's dictates; causes individualistic consumer reaction in the marketplace - to the point of purchase refusal if desires are not met. This expresses itself in overt criticism, lobbying and myriad group and non-group activities, to influence the market and the manufacturers, economically, politically and socially.

In other words, the consumer is exhibiting an "adapting behavior" pattern, which will increase in intensity as the society becomes more affluent.

If consumer response to product differentiation can be looked at as a form of adapting behavior (inelastically demanded product for which according to empirical evidence and theory the substitution effect of least cost is greater than the income effect) no manner of reinforcement control can influence the buying of that good which is cheapest in time, money, or convenience. As some of our manufacturers have found to their sorrow (the latest bankruptcy in men's clothing being century-old Botany Industries), no amount of reinforcement control could possibly influence an adapting society, which is exactly what happened.

The world of advertising media in our present "free society" has been geared to the development of reinforcement, stimulus-response models and not cybernetic control, because the media has usually assumed adaptive behavior on the part of the consumer. By assuming that the consumer is an adaptive personality and therefore learns what is being taught without wanting to use learning as a means of further expression, the media in advertising have assumed that constant repetition would cause the consumer to learn, without thinking either of the repetitive method or of the application. Reinforcement control without obtaining consumer reaction (other than in the most general fashion of like or dislike, I or nul-I, percentage listening versus percentage not listening, percentage tuned in versus percentage not tuned-in, and the entire world of Neilsen Ratings) is solely for an adaptive behavior society.

Cybernetic control, on the other hand, assumes that the response of the media to the needs of the consumer dictates the type of approach to the consumer and that this approach is changeable as the consumer responses are obtained. The chart (Appendix A) shows the differentiation between reinforcement and cybernetic control.

In the early nineteen-sixties, President J.F. Kennedy sent, for the first time, a message to Congress on Consumer Rights.

1. **The Right to Safety** - To be protected against the marketing of goods which are hazardous to health and life.
2. **The Right to be Informed** - To be protected against fraudulent, deceitful or grossly misleading information, advertising, labeling, or other practices, and to be given the facts needed to make an

informed choice.

3. **The Right to Choose** - To be assured, where ever possible, access to a variety of products and services at comptetitive prices; and, in those industries where government regulations are substituted, an assurance of satisfactory quality and service at fair prices.
4. **The Right to be Heard** - To be assured that consumer interests will receive full and sympathetic consideration in the formulation of government policy and fair expeditious treatment in its administrative tribunals. [13.4]

It should be noted that of these four Consumer Rights first mentioned in Kennedy's message, three are solely for an adapting behavior society: the right to be informed, the right to choose, and the right to be heard, which are of course, the basis of cybernetic control or feedback.

CYBERNITICS AND EARLY CHILDHOOD EDUCATION OR ADAPTING BEHAVIOR AND EDUCATION

I now consider some theoretical aspects of the concept of "Self-Controlled Interactive Learning Systems: SCILS" and its relation to learning as well as to some recent experimental findings. This problem of understanding learning, has reached crucial proportions as is clearly indicated by the current controversies on the validity and/or substantiation and/or justification of reinforcement theories of learning. The distinction to be made between cybernetic control and reinforcement control delineates clearly the difference between sensory feedback and the feedback concept of knowledge of results or reinforcements, and has far reaching meaning for the application of control theory to human activity.

An experimental environment of a "SCILS" (Self-Controlled Interactive Learning Systems) nature has been researched since 1967 at the Early Childhood Center, a laboratory school at Drexel University under the direction of the Department of Human Behavior and Development. Findings suggest that early involvement (ages 2.7 to 6 years) seems to be effective in specific language and reading skills including alphabet recognition, reading ability, language facility, and typing ability. Unexpected results in areas other than academic skills have become evident, particularly in the areas of emotional and social development. Children who were unable to use a similar non-automated program, owing to rather severe behavioral difficulties, were successfully involved in the automated program.

FEEDBACK-CONTROL

The principle of feedback-control was recognized by training psychologists more than 25 years ago. However, its introduction as a formal behavioral concept dates back to 1948, when Wiener published his book "Cybernetics." His term cybernetics called attention to the study of human control mechanism and the principle of feedback control.

Feedback control visualizes an elementary system of control by which the sensing elements of an organism can obtain information and feed it back internally for guidance of its operative motor nerve centers. Such feedback was a commonplace of the physiologist long before the engineer found common ground with him in "cybernetics". This principle of steersmanship by feedback has undoubtedly played a very important evolutionary role in animal life. Possible even before life appeared.

Behavioral scientists have indicated a rather widespread acceptance of the principle of feedback. However, feedback and knowledge of results is being used synonymously and knowledge of results is thought to function as reward as well as information. In the Psychological Abstracts feedback is indexed as "See also knowledge of results, Reinforcement". One can thus see why many theorists took the term feedback to mean reinforcement.

In the latter analogy the feedback signal is interpreted as having reinforcing properties. And the smaller the magnitude of the error, the greater the reinforcement value of the signal. It is understood then that the response that minimized error is presumably strengthened or learned.

It has been observed experimentally, that providing knowledge of results rather than reducing or withholding knowledge, does lead to more effective learning. And, it is true that immediate knowledge is more effective than delayed knowledge. But, this does not automatically enhance efficiency of performance and learning. Yet, it is generally assumed that learning can be enhanced if it is followed by reinforcement.

In other words, dynamic sensory feedback provides an intrinsic means of regulation motion in relation to the environment, while knowledge of results given after a response, is a static after-effect, which may give information about accuracy, but does not give dynamic regulating stimuli. Dynamic feedback indication of "error" or "disturbance," would thus be expected to be more effective in performance and learning than static knowledge of results.

Furthermore, the efficacy of reinforcement assumes an active need or drive state while feedback theory assumes that the organism is built as an action system and thus energizes itself. Hence, body needs are satisfied by behavior that is structured primarily according to perceptual organizational mechanisms and require programs that communicate [3, 4, 5, 9, 22].

Systematic transformation of sensory-feedback patterns are affected be they use of tools, by the symbols, socio-psychological, economic, or other instruments. Opposed to this, reinforcement theory describes learning as due to the effects of reinforcements that bear no systematic relation to the different kinds of behavior learned.

We can now judge why reinforcement of a child turning his head to the right, being reinforced by a sucrose solution, sucked from a bottle, takes hundreds of tries, with a 30% rate of failure, and Bruner's baby with a $20,000 pacifier only a few tries, about five seconds, before he learns to focus a picture of his mother, and he isn't even hungry. The bottle experiment is a stumulus-response model, while the pacifier experiment is a true cybernetic feedback model [3, 4, 5, 27] (See Appendix A)

TRANSFORMATION OF CONTROL

A theory of behavior organizations should enable us to conceptualize an orderly progression from relatively simple overt response patterns seen in very young children to the complicated skills, symbolic responses, and other abstract thinking that an individual can exhibit. These human processes can be analyzed in terms of systematic transformations of sensory-feedback patterns. Implicitly this denies the general validity of association and reinforcement models.

What appears to be different types of thinking may actually be considered as differences in patterns of feedback control. There are no distinctive categories in learning except in a general descriptive sense[18].

1. Verbal Learning and instrumental learning differ because the systematic transformations of closed loop regulation of behavior are different in these two areas.
2. Instrumental learning and unaided psychomotor learning differ since the use of tools and machines involves spatial, temporal, and kinetic transformations of feedback. This in turn changes the

pattern of control.

3. Psychomotor learning incorporates the feedback mechanisms of manipulative movements.
4. Orientation learning involves integration of the larger transport and postural movements of the body into more general pattern of control.

Classical conditioning differs from orientation learning because the subjects are restrained and deprived of much of the varied sensory feedback used in normal adaptive responses. Feedback theory can account for a variety of behavior, from relatively simple overt responses to complex overt and symbolic skills. Thus, cybernetic research in learning may well provide a framework for understanding disparate results obtained in different experiments.

COMMUNICATION AND SOCIAL DEVELOPMENT

In communiciation there are at least two different systems that can be involved. There can be communication with a person or communication without a person, or rather, communication by means of an intermediary, an object. It need hardly be emphasized that communication through objects is different than communication with a person.

Up to now, education and training has been dependent on relations between people. Usually a child learns by being in communication with another person, be it another child, or an adult. This is the dimension of the field up to the present.

In the case of communication through objects, there is a direct relationship between the individual and the object. Such a system is different from the one in which there is direct contact between people.

As a result, the field of teaching systems is just that much enlarged, although interrelations between people and objects are all subject to the person to person relations.

All of teaching is about (1) science (object-to-object relation); (2) applied science (person-to-object relation); (3) humanities (person-to-person relation). Person -to-person relations is common to all teaching, be it between pupil and teacher or parent and child, and so on. However, in using equipment in teaching-learning (pupil and object) there is now a different system involved. A new continent has been discovered, a new dimension, a new era where the relation involved is people to objects. Other areas will probably develop, but this one has a place for technology.

Lest one immediately worries about the competition this may present with the other system, consider that an airplane does not interfere with walking. Furthermore, we suggest that this kind of equipment, SCILS (Self-Controlled Interactive Learning Systems) should be used at an early age. It is best suited for use early on since it is then that all systems of communication can be engaged and developed. For instance, in the case of the airplane, it should be used for long distances, and not to cross a street. It is much harder to use SCILS later on in life when it is used for remediation.

People-object relation is as essential as people-to-people relation. However, people-people relations work best when people share similar experiences. People-people contact is basically inhibited by different educational backgrounds, inhibited by the fact that people have not had similar past experiences. But, if both teachers and students had people-object relationships, and share some experiences, then education, which is people-people relation, becomes easier to achieve.

SOCIAL AND SELF-CONTROLLED ENVIRONMENTS

The social environment is a matter of give and take, but relations between people-object are not. It is argued that a child who has not yet established a people-people relation, an autistic child for instance, runs the risk of establishing only a people-object relation and may remain satisfied with that. But it may well be that it is the other way around. A person may be able to be involved in a people-object system, the non-give-and-take system. A person involved in a system relation with objects has learned that there is a certain affinity possible with the outside world which is relation between people and objects. Then, the next possible step may be when one of the objects in the outside world is in fact a person. It is thus possible that a relation which does not have a give and take may soon change into one that does. Experimental evidence at Drexel University's Early Childhood Center, in working with mentally and physically handicapped children, seems to support this. [31].

EMPIRICAL SUBSTANTIATION IN EDUCATION

Several studies investigated the longterm achievement of Get-Set children who participated in the SCILS (Self-Controlled Interactive Learning System) program at the Drexel Early childhood Center, and who are now enrolled in the Philadelphia public and parochial schools.

The SCILS program involve the use of a "talking typewriter", and a "talking page", to teach reading, and mathematics to children at the Drexel Early Childhood Center. Its premise is that learning involves both the acquisition of skills, training, and the formation of new concepts, education. The proper use of the instructional technology is to enable the learner, the child to acquire skills which can be utilized in new concept formation. The teacher's role then shifts from concentration on training to involvement in education. However, if instructional technology is to be effective it should incorporate choice, control by the student, responsiveness to the student, and instantaneous feedback to the student which allows for self-regulation and self-correction. (Appendix B).

Twenty-two Get-Set children who were enrolled in the Drexel Early Childhood Center for an average of 2.54 years were the subject of these studies. Thirteen of the subjects were followed through the sixth grade, four through the ninth.

Treatment consisted of daily sessions, no more than twenty minutes in length on a volunteer basis; the primary component of this treatment was playing with a "Talking Typewriter", "Talking Page", and "Voice-Mirror." Courseware was developed to accentuate auditory and perceptual strengths of subjects and to remediate weaknesses secondarily. The objectives of the programming were the demonstration of skills in (1) recognizing alphabet letters, (2) typing letters from dictation, and (3) reading words orally. Monitors also worked with children on individual experience stories which were then programmed for the Talking Typewriter.

Commencing with kindergarden, the following tests were given to the children annually:

Peabody Picture Vocabulary Test (PPVT)
Wide Range Arithmetic Test (WRA)
Informal Word Recognition Test (IWR)
Informal Reading Inventory (IRI)
Spache Comprehension Test (Spache)

California Achievement Tests (CAT) scores and all subtests were made available annually through the cooperation of the Philadelphia Board of Education

Using correlational and regression analysis, the following results were obtained:

- Achievement of children in the areas of reading and arithmetic correlates significantly with time on equipment (SCILS time).
- Achievement of low SES (Socio-Economic-status) children in the areas of reading and arithmetic correlates significantly with attendance at the Early Childhood Center.
- Pre-mean IQ 71.8 (with two children untestable).
- Post-mean IQ 94.6 (with the two previously untestable children now included).
- No significant correlation between IQ and achievement.
- No significant correlation between change in IQ and change in achievement.
- All children, with a minimum of thirty hours of instructional time in SCILS, regardless of pre-IQ level, are achieving at or above grade level in reading and reading comprehension.
- Long term goals appear to be sustained nine years after the children have left the Center.
- The long term gains are incremental, that is, increase year by year.
- All children with a minimum of 10 hours of instructional time in SCILS, regardless of pre-I.Q. level, are achieving at or above grade level in reading.

By present indications use of the SCILS program in the early childhood years insures better performance in reading, reading comprehension and arithmetic than would otherwise be the case. It also leads to increasing level of understanding, of comprehension, and its effects do not disappear but increase as the child grows older. Use of the "Talking typewriter", "talking page", and "voice-mirror" has a significant correlation with performance that increases with age. In grade 1, none was found. By grade 2, SCILS time begins to relate to Wide Range Reading. By grade 3, 4, and 5, it relates much more with WRR and even more with IWR.

UPDATE 1989

In June 1986, I was visited by A. Levita, involved at the time with early education in Israel at Haifa University. She spent a week at Drexel University and went back to Israel. She was able to start up a part-time program in two kindergartens in the new immigrant intake town of Hadera under the sponsorship of the President of Menashe College, Mr. Joseph Menahem. This program is based on SCILS' philosophy of education and its present methodology which uses microcomputers (Computer Assisted Instruction - CAI).

The work progressed to the point that some months later the Israeli Ministry of Education expanded the program, from two sites to sixty sites. By Fall of 1987 the program was again expanded, and placed in one thousand sites. Levita was appointed Director of Educational Technology at the Ministry of Education. As of Fall 1988, all two thousand kindergartens in Israel, which includes all low SES (Socio-economic status) children, supported by the Israeli Ministry of Education, have such a computer program.

I have been closely involved with the program since its inception and have been on site for two weeks, both in June 1987 and 1988.

Two major findings from the work in Israel replicate as well as expand the findings of the research at Drexel University as well as those of the Cornell Consortioum Evaluation of the Head Start Programs:

- a significant number of children are less likely to go into special education in first grade.

- a significant number of children are less likely to be kept back in kindergarten to repeat the year.

Additionally, at Menashe College (Tel Aviv University), in Hadera, Israel, seven hundred teachers have been taking in-service courses in Computers and Education.

The cross cultural applications may have broad implications for the theoretical underpinnings of the philosophy of education that guides the application and the Communication Computer Assisted Instruction (CCAI) model which guides the methodology.

CONCLUSION

We have found a pattern of "Adapting" behavior where the environment is changed to suit the requirements of the system, as opposed to the system changing to suit the requirements of the environment. This is a true cybernetic activity in response to economic or other input signal. Only education is correlated with this pattern of behavior. Not even race is so correlated. Exhibited adapting behavior is evidenced in a cybernetic situation wherein the individual takes choices, relates to information selectively, and refuses to be "brainwashed" or influenced in choosing what he desires. This applies in every political materially oriented environment, such as the new towns in the U.S.S.R.

A technologically based cybernetic learning environment based on this theory demonstrates continued incremental longterm gains in reading with early intervention (ages 3 - 6).

Steg and Schulman found adapting behavior or learned behavior, in a situation that is not a learning situation, for instance, in a consumption pattern. This adapting behavior is exhibited when a particular economic threshold is reached. The individual quickly exhibits this behavior in educational, social, and political areas as well. The economic threshold is where the majority of the nation becomes middle class, or to put it in economic terms, when the majority have achieved discretionary income.

It is, therefore, postulated that all societies which have attained freedom from abject want will eventually approach the point at which affluence in time, goods, and/or money will make it necessary for societies to respond to adapting behavior, a distinctive human transaction. Of necessity, this implies technological development. Such patterns of adapting behavior can be pervasive in all human relationships and in every field of endeavor.

In summary, the term C^3I (Communication, Command, and Control and Information) or more academically "Cybernetics" is well-known and comfortable in the "simple" world of high technology, military strategy and weapons systems. Having achieved some insight into behavior in the much more complex world of social system we may be ready to attempt some modest contribution.

EDUCATIONAL SIGNIFICANCE

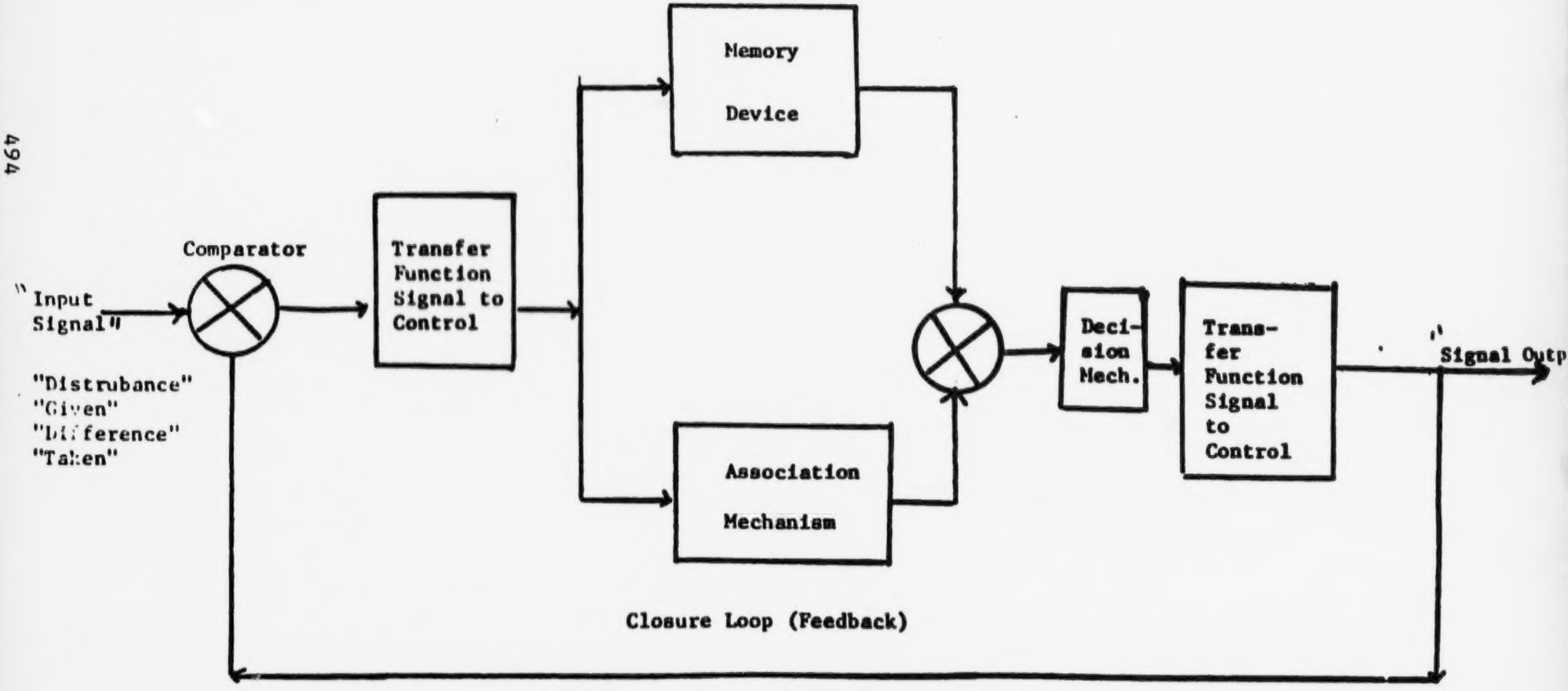
The literature is replete with studies which appear to indicate a continual decline, a deceleration in the acquisition of skills as well as functional, measured intelligence. Much of this deceleration in educational acquisition has been attributed to the retarding effects of certain environmental conditions. The crux of the matter may well be the decided necessity, especially during the formative years, of three to six, to provide for the children, opportunity to learn. For most children, this evidently is not a problem, since learning takes place with little apparent difficulty. But for a substantial minority, this learning does not take place as normative data would anticipate with a consequent decrease in self-esteem, and an increase in impulsive, sometimes destructive behavior towards themselves and others [31].

Whether or not these levels of achievements will be further maintained and accrued to remains to be seen through further longitudinal study of these children and of others leaving the Center. However, the levels of significance are so striking in the time on the equipment and the time enrolled in the early childhood program with present achievement, that it is not probable that this performance pattern will break down in the future to any great extent [28, 30, 31]

It has sometimes been the case that the educational system, in general, in its passion to accept or seize tools without paying attention to evaluations that have been made, land in difficult and murky situations.

Even with a program such as "Writing To Read", the full body of the report has been released to a few selected individuals in selected organizations, outside of ETS (Educational Testing Services) and IBM. However, it has not been sufficiently broadly available to be able to respond to it in an open forum.

Remarkably, it is to be noted that as of 1988, "reading skills continue to profit least" from computer applications [38].


Comparator
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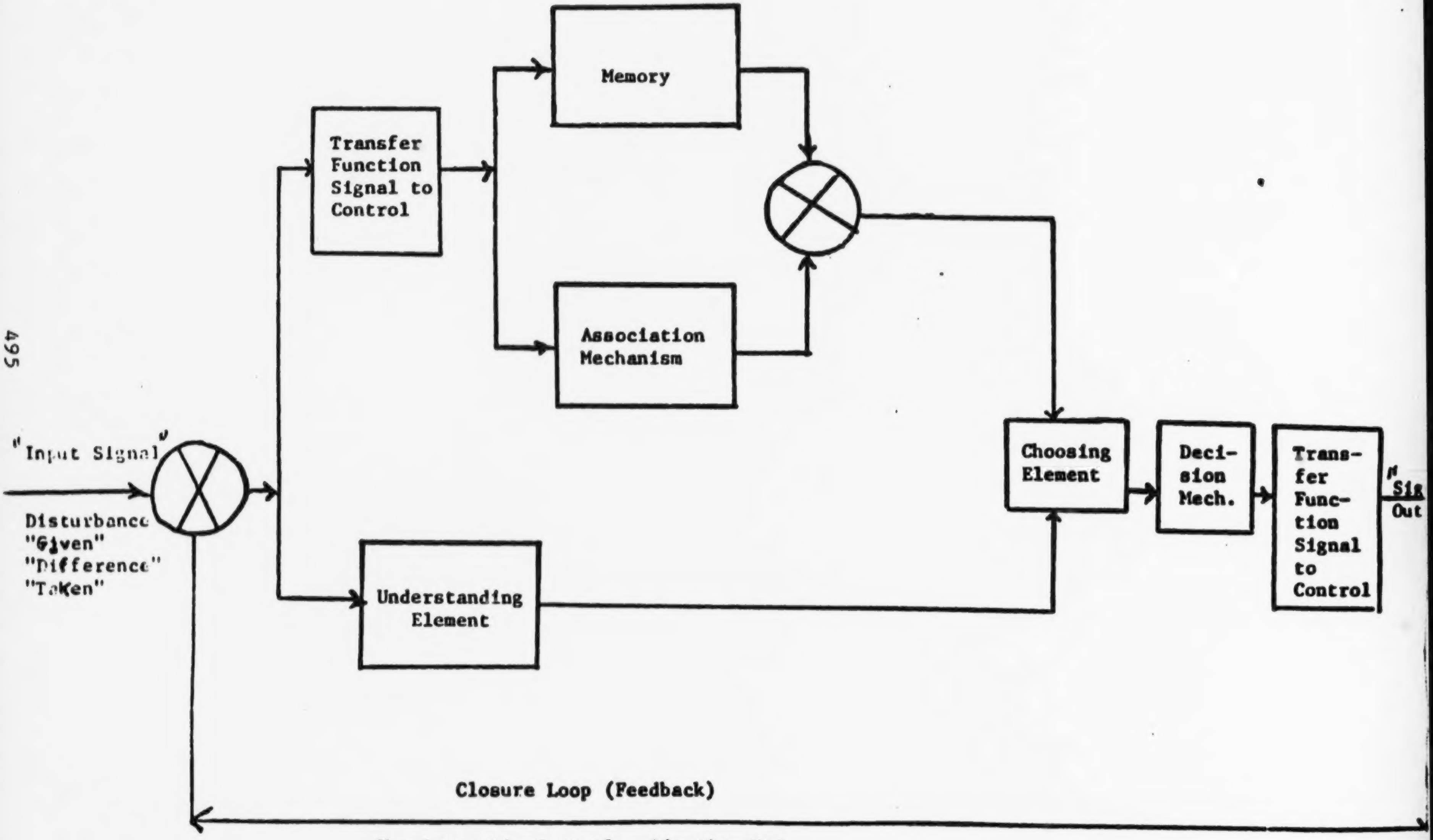
"Taken"
Transfer Function Signal to Control
Memory Device
Association Mechanism
Deci-sion Mech.
Trans-fer Function Signal to Control
"Signal Outp
Closure Loop (Feedback)

Machine Type Learning (Adaptive Mode)

Figure I


"Input Signal"
Disturbance
"Given"
"Difference"
"Taken"
Transfer Function Signal to Control
Memory
Association Mechanism
Understanding Element
Choosing Element
Decision Mech.
Transfer Function Signal to Control
"Sig Out
Closure Loop (Feedback)

Non Automatic Control - Adapting Mode

Figure II

APPENDIX "A"

Cybernetic Control Model (Communication-Control and Organization Model - C^2O)	Conditioning Model
Action	Reaction
no physiological deprivation	physiological deprivation
no physical restraints	physical deprivation
internal control	external "control" possibly leading to some to some activity
voluntary control	"stimulus control"
intrinsic means of regulating motion	extrinsic reinforcement schedule (leading to extinction if not used)
means and ends not bonded	means and ends are bonded
action has a systematic relation to the learned behavior	action has no systematic relation to the learned behavior
learning requires no external reinforcement	if learning occurs, it is transient, requiring external reinforcement
behavior is the control of input	behavior is the control of output
dynamic continuous feedback	static after-effect of knowledge
almost instantaneous learning (few seconds)	many trials for learning (if conditioning occurs)
self-determined learning	doubtful feasability of conditioning
primitive adapting system (i.e. uses internal and external sources of energy to change the environment)	system adaptive only if and when successfully engaged (i.e. may respond to environmental "stimulus")
(Sucking) $C \rightleftarrows E$ (Focusing)	Cause -----> Effect
information is circular (fedback)	information is unidirectional (linear)
closed loop	open loop

The designs of the hardware and software components of SCILS embodies educational principles which are encapsulated in its name, Self-Controlled Interactive Learning Systems. Specifically, learning in the SCILS program involved the following:

- Voluntary access to technology for learning.
- Choices of time of day and content of courseware.
- Multi-sensory engagement of the learner.
- Learner control of the environment.
- Instantaneous feedback allowing the learner to evaluate his actions in relation to his goals.
- Responsiveness to the actions of the learner.

These features enable substantial learner progress as was seen in the earlier discussion of the SCILS Program at Drexel. These learning principles are not age-specific or culture-specific. Rather, they are principles which can be universally applied to any learner.

FOOTNOTES

[1] The modest empiricism in human transaction herein exemplified is developed from a general theory of adapting behavior [20, 21, 23].

[2] The term, "error input" is an engineering term commonly accepted to mean a disturbance.

[3] In large social systems, the difficulty is the variety in the disturbances that is regulated against, particularly since there is a limit to the amount of regulation and control that can be achieved. This is contrary to what is usually thought of a s size being the critical feature. [1:244]

[4] The largest industry in the Soviet Union is smuggling and other forms of illegal or underground activities including reproduction of banned books, records, etc.

[5] Where the majority of consumption is descretionary (i.e., non-necessity) an affluent society can be defined as one which has reached the last stages of industrialization, or is a post-industrial society. The post-industrial society has a substantial majority of its labor force in white collar, technical or professional occupations. The U.S., the Scandinavian countries, the Low-countries, (Netherlands, Belgium), Luxembourg, and West Germany are some examples of post-industrialized nations.

[6] It increases for services.

[7] As opposed to the "Psychological Abstract" definition of feedback as 'knowledge of results', response to stimulus, or reinforcement.

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A CASE FOR SECULAR ETHICS IN SCIENCE, TECHNOLOGY and SOCIETY

Robert E. Baker

I can think of a few basic reasons why people attend conferences. It looks good on the résumé. It's an opportunity to get away for a few days. The host city's an attraction. There are interesting people to meet.

However, I suspect the basic reason many of you are at this conference is concern and, in some cases, alarm regarding such issues as unbridled genetic research, continued environmental pollution, covert chemical weapons development, the ongoing pursuit of Star Wars technology. And whether we're in government, education, service organizations, or business, we sometimes feel conflicted by either the implicit or explicit expectation that we accept positions and assumptions about such issues. Being an operator at a nuclear power plant can be a tough job if one questions the merits of nuclear energy.

In my view it is undeniable that the problems identified in the sciences, technologies, and their implications for society, i.e., people, entail values and moral issues. And it is equally undeniable that ethical literacy is as critical in a democracy as is scientific and technological literacy . What, then, constitutes a viable basis for ethical thought, one that will lead us to resolutions of moral conflicts through reasoned consideration and not merely through "gut" reactionism?

Simply, there are two sources for a sound ethical system of thought: *external* and *internal*.[1] By way of example, an external source might be civil or religious law; for an internal source it might be conscience or faith. Similarly, there are two basic types of sources for ethics: *religious* and *secular*. Civil law as an external source is secular, religious law religious. Again, faith as an internal source is religious, conscience secular (See Figure 1).

These sources and types interact to various extents.[2] My purpose here is not to argue against an ethics based in religion, though in a full presentation of my position I would need to do that; rather, I want to open our thinking to the notion that those of us who are not religious do nonetheless have a basis for a viable ethical system. To go a step further to reveal my position without defending it here, I maintain that the internal-secular ethic is the most defensible and viable ethic, even more sound than the religious-external or religious-internal.

For the philosophers in our midst, another way of stating my view is to call it "ontological ethics" since the case for a secular ethics is based in the nature of being.[3] There are essentially three views I want to mention to support an ontological ethics: 1. The Futures View, 2. The Individualistic View; and 3. The Societal View (See Figure 2).

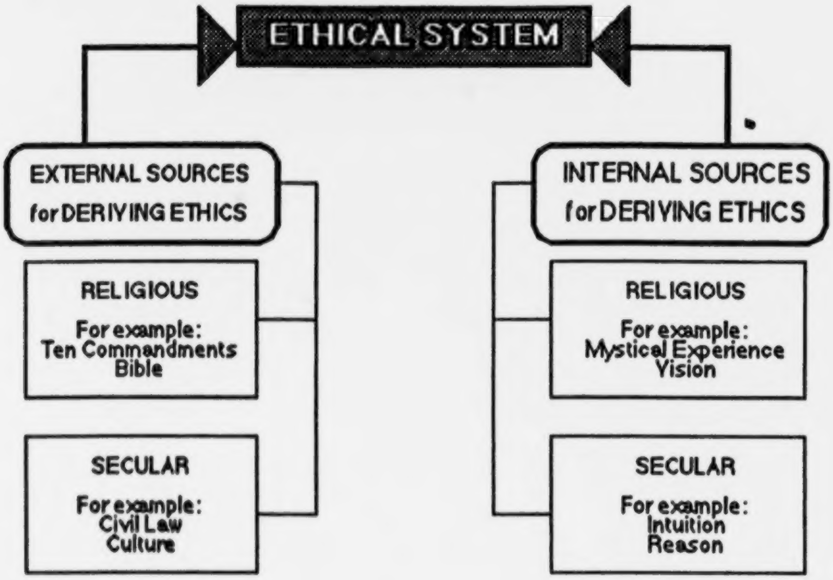
ETHICAL SYSTEM
EXTERNAL SOURCES for DERIVING ETHICS
RELIGIOUS
For example: Ten Commandments Bible
SECULAR
For example: Civil Law Culture
INTERNAL SOURCES for DERIVING ETHICS
RELIGIOUS
For example: Mystical Experience Vision
SECULAR
For example: Intuition Reason

Figure 1. *Sources for Deriving an Ethics*

1. The Futures View

Futurists and future studies represent a field of inquiry closely allied with science, technology and society.[4] Among many critical characteristics of the field there are two I would highlight: *1. The holistic view of time, i.e., the past, present and future constitute a continuum from which we can develop understanding of the human journey by beginning not just with the past, history, but also with the future, or possible futures; 2. The idea that we can deliberately create the future.*

These two approaches or characteristics yield an internal basis for ethics. Seeing the human drama as a continuum and holistically reveals the systemic nature of all humanity, living and dead and yet-to-be. Theologians have a concept similar to this in what is called "the corporate solidarity of humanity." In literature the concept is most popularly seen in Donne's immortal words: "No Man is an island, Entire of itself; ... any man's death diminishes me, because I am involved in mankind, and therefore never send to know for whom the bell tolls; it tolls for thee." [5]

Implied in the systemic idea is that what I do affects others, for good or for ill, wittingly or otherwise. There is, unfortunately, a plethora of negative examples, such as alleged connections between industry and cancer, nuclear waste and our great great grandchildren, advertising and anorexia nervosa. Similarly, what a nation does — or does not do — affects other nations and peoples. There has never been a time in history that this has been as accurate a statement as today. We have realized MacLuhan's vision of a global village. Responsibility and accountability are inherent in the systemic notion. Even egocentrism has it that "what goes around, comes around," i.e., my actions that influence others eventually come back to influence me.

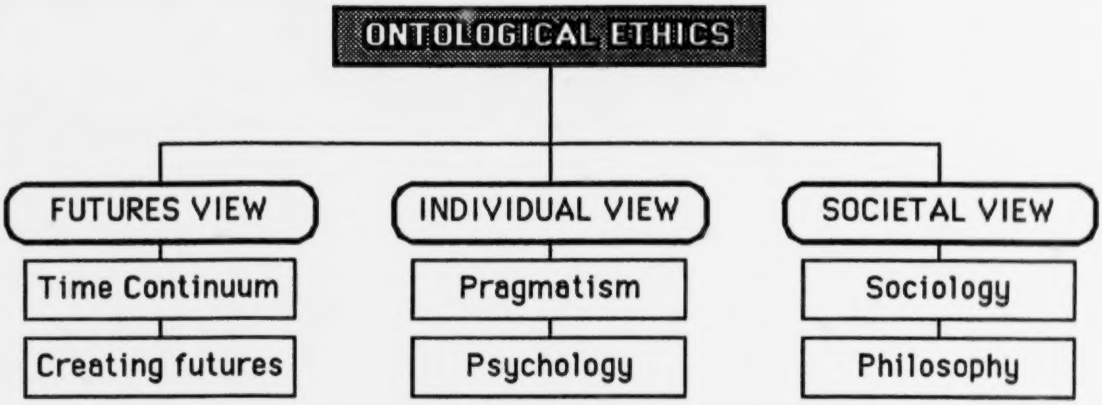

Figure 2. *Views for Defending an Ontological Ethics*

Futurists also proffer the idea that we are not merely victims of our past, condemned to repeat it or locked into the inevitability of trending or extrapolation. We can, we say, deliberately shape or create our collective future. As information technology improves, this futurist dictum becomes more realistic. Never before in history have we had access to so much information and knowledge; never before have we had such powerful and sophisticated tools to analyze and evaluate information and knowledge. For instance, the computer I use at home and in the office — an Apple Macintosh — puts me in contact with universities throughout North America, Europe and soon with every nation's major institutions of higher learning. At no cost to me. Moreover, I have access to databases in the sciences, humanities and social sciences and can conduct research, develop a bibliography, or do statistical analysis.

Entailed in this new access and ability is a strengthening of the argument of responsibility for the future. We are ethically culpable for what we do regarding the future. Or so futurists assert.

2. The Individualistic View [6]

By "individualistic view" I mean a view that considers ethics from the vantage point of the individual rather than from the futures view or from the societal or community view. And while there are many approaches to this view I would mention only two, namely the *pragmatic* and the *psychological.*

The pragmatic is easily dispensed with and was alluded to earlier in the proposition, "What goes around comes around." Simply, an ethics may be determined from an egocentric perspective, i.e., what I do to or for others — or to or for the natural environment — is considered only in terms of my actions ultimate results for my life and well being. I will not steal because I might get caught and it's against the law. Or I will allow toxic waste to leak from my plant because profits will be higher and, besides, tracing possible pollution or sickness to the waste my plant has leaked is unlikely. And more unlikely is prosecution for same. Or, on a positive note, I will not allow toxic waste leaks because I have a reputation to maintain and that is good for company profits.

The other approach to the individualistic view is psychological. Studies in the behavioral sciences suggest that an inherent part of the human psyche is a conscience, at least to the extent that there is a cognitive element of discernment that there is a right and wrong in human behavior. It's absence denotes a pathology. Even the most deplorable behavior, such as the actions of Nazi war criminals, finds self-justification in the ethical standard, "I was following orders," or "I am loyal to the Führer." Or, to bring it home, "I was protecting national security."

Whether this conscience is inherent in the psyche or the result of socialization is not a mute question, although results in animal primate research make a combination of nature and nurture most likely. However, I do not have time to explore it here but just to state my position: Inherent in the human psyche is the propensity and capacity for "learning" what is acceptable or right behavior and what is unacceptable or wrong; yet the final conclusions regarding questions of right and wrong are chiefly, I believe, determined by one's cultural environment, coupled with the self interest for personal acceptance and well being. It is a matter of *both* inheritance *and* environment, *both* nature *and* nurture.

3. The Societal View

When I speak of the societal view I have two approaches in mind: the *sociological* and *philosophical.* This view is contrasted with the individualistic view inasmuch as it seeks a rationale for ethics from an examination of society or community as it bears upon the human psyche, the internal person.

While sociology fundamentally examines social institutions with disinterest and, ideally, without value judgement, and describes their machinations, characteristics, and interactions, such descriptive reporting leads me certain conclusions regarding values. For instance, sustainable stable societies have been those in which there is a symbiotic quality among their institutions; or those that have been the result of autocratic authoritarian rule in one political form or another. Yet even in the latter there is profound respect for the interdependence of the institutions of those societies.

To call a society a "thriving" one is qualitatively different than to call it a "surviving" one. And to critique, say, a communist society from the view of a democratic society is unsound since historical and other circumstances vary widely. My point is not to affirm one political structure as better than another but to emphasize that thriving stable societies share the common value that certain components, if not all, are recognized as interdependent.

As never before in history, contrasts between societies, whole nations for that matter, are becoming very gray. Territorial boundaries remain but the boundaries that set peoples against peoples seem to be crumbling. Witness the profound changes in China and the Soviet Union. This leads me to the notion that in our various efforts to thrive as societies we see a potential foundation for ethics in matters of global concern, such as environmental pollution. It is an interesting aside to think that Earth itself may provide the prime mover for world peace and cooperation.

The approach of philosophy, of course, differs from that of sociology and offers up different ideas for supporting an ontological ethics. The chief idea, an idea that set Western philosophy in motion with the pre-Socratic philosophers, is the primacy of reason in human experience and thought.

Whether I look at the developmental stages of my son from infancy through young adulthood or look at the human saga, I certainly conclude and accept that emotions, feelings, play a significant and treasured role in our lives as individuals and as groups and often lead to the passions of love and war. But I also conclude that our ability to think critically, to analyze, to evaluate, in short to reason, is the cornerstone of human society and civilization. Reason and emotion is not a case of either/or but of both/and. Emotion without reason is barbaric and destructive. Reason without emotion is empty, directionless, pointless. Each without the other is pathological.

Trying to define "sanity" may make a psychologist insane or turn a court trial on its ear. Yet the philosopher discerns that what psychologists tell us is that the thriving individual and society are ones in which reason guides actions. Ontological ethics, then, finds as its prime axiom the primacy of reason in matters of moral judgement.

We may use emotions to persuade others of the urgency of some ethical issue, such as nuclear arms, or, as Jeremy Rifkin did last year at this conference, to arouse our concerns about genetic research and development.

But the validity of the issue is determined not by moving rhetoric. It must be determined by reasoned analysis and an ethical system founded in reason.

Conclusion

My remarks today are addressed to those of us who reject a religious basis for the ethical issues we face. Nonetheless, I would argue that the internal secular ethics, ontological ethics, that I propose does not necessarily preclude a religious aspect or necessarily negate a religious ethics.

It would be presumptuous to think I've actually made a case for a secular ethics in such a short presentation. But it is not unrealistic to hope that I've made one final and critical point, namely that the ethics entailed in the scientific and technological issues we identify require the same care of thought, information retrieval, and examination as do the specific sciences and technologies in question. In truth, doing science and doing ethics do not require such different skills. Likening ethics to art we can look to Jacob Bronowski to see the soundness of this claim. I end with some of Bronowski's own words:

> *What is true of poetry is true of all creative thought. . . The values by which we are to survive are not rules for just and unjust conduct, but are those deeper illuminations in whose light justice and injustice, good and evil, means and ends are seen in fearful sharpness of outline.*[7]

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[1] Philosophers generally make a distinction between teleological and deontological systems of ethics that is not incompatible with the distinction I am making here. In addition, it should be noted that I favor a teleological view in concert with my assertion of an internal secular basis for ethics.

[2] The notion of a subjective "inside world" and objective reality, "outside world," is one that has received a great deal of attention, especially in philosophy. Kant was one of the first to deal effectively with this duality and pointing out that the divide between the knower and the known is unbridgeable. To put the problem another way, William Irwin Thompson, among many futurists, has noted that we do not view nature as through a window because we are part of nature (Passages About Earth).

[3] Ontology is a branch of metaphysics, the latter concerned with the nature and scope of reality, and ontology is concerned with the nature of being and existants.

[4] For a definition and explication of "future studies," see: Baker, Robert E., "Future Studies: Defining Our Way," *Futures Research Quarterly*, 55-59 (Fall 1987).

[5] Donne, John 1572-1631, Devotions (Meditation 17)

[6] It is not my intention here to support the idea of American individualism but merely to make a distinction between this and other views. Nonetheless, my ideas do need further reflection based on such works as: Robert N. Bellah's Habits of the Heart, Philip Slater's Earthwalk, and Christopher Lasch's The Minimal Self.

[7] Bronowski, Jacob, *Science and Human Values*. Harper and Row, New York, 1965, p.73.

VALUES CHANGES NECESSARY FOR A SUSTAINABLE SOCIETY

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VALUES CHANGES NECESSARY FOR A SUSTAINABLE SOCIETY

by G. Ray Funkhouser

This paper has a vast potential for unpopularity. Its thesis is that the core values of many people at this conference are helping to drive America away from the goal of a sustainable society and toward an economic/ ecological (eco/eco) catastrophe. Some may remain unruffled by this assertion, either because they have no interest in a sustainable society, or because liberal values don't give them a warm feeling. But those who support both liberal values *and* the ideal of a sustainable society may not be drawn to cuddling up with my analysis and proposed solutions.

"Alternative economists" advocate the *sustainable society*, a stable political-economic system existing in perpetuity. The World Commission on Environment and Development[1] defined this as:

> "paths of human progress that meet the needs and aspirations of the present generation without compromising the ability of future generations to meet their needs."

According to Lester Brown[2], this would mean stable population size, more efficient use of energy and wider dispersal of people and industrial activity. Herman Daly envisions a political economy based on "stewardship"[3].

While we may disagree on specifics, the idea of general comfort and happiness that can continue indefinitely at steady-state has obvious appeal to a world facing multiple threats of over-population, pollution, ecological degredation and exhaustion of resources. Such a society might not enjoy our present high material standard of living, but many question whether our current standard equates to optimal quality of life anyway. In any case, to attain a sustainable society in a democratic and market-based system would require the assent of the public. That would flow from a national consensus on values: What goals should we as a nation (or a species) pursue? And, how should we properly pursue them?

In this paper I trace the evolution of contemporary American values, with special stress on the values that drive and constrain the day-to-day behavior of ordinary people -- the true decision-makers in a market-based economy and a democratic political system. It appears that our modern, so-called liberal values favor and support our present, consumption-oriented social order. These same values undermine and override the more traditional values necessary for sustainability, in ways that many may not realize. My thesis is that consumerist values must be repudiated if the sustainable society is to be realized. This implies an overturning of some dominant themes of contemporary American society, including certain core values of its intellectual establishment.

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[1] *Our Common Future*, p. 43.

[2] *Building a Sustainable Society*, p. 247.

[3] *Economics, Ecology, Ethics: Essays Toward a Steady-State Economy*.

THE EVOLUTION OF VALUES

Economists and social scientists tend to disdain ethical values, preferring to attribute human motivations to interests, reinforcement schedules and unconscious forces. But it doesn't take a professional philosopher to notice that ordinary people in their everyday lives do a lot of things because they think they are the "right thing to do," while eschewing other acts because they are the "wrong thing to do."

The 20th century is notable for its intellectual acceptance of the belief that values are relative, not absolute[4]. But religious believers (who, incidentally, quite outnumber the unbelievers) disagree. For example, according to the tenants of Jewish, Christian and Muslim faiths, God revealed universal and absolute rights and wrongs. Follow them and you will be blessed; transgress them and be damned. Psychologist Donald T. Campbell in 1975 delivered a most remarkable presidential address to the American Psychological Association[5]. He reviewed a variety of cultures at many points in time and discovered some values to be nearly universal. Nearly all human cultures indoctrinate their members to believe in altruism, conformity, generosity, deference to authority, and honesty. At the same time they preach against selfishness, pride, stinginess, greed, gluttony, envy, lust, theft, cowardice, nonconformity, disobedience and stubbornness. Campbell saw these social values as providing the necessary balance between the interests of individuals and the needs of the group. The "wrongs" are self-serving motivations. The "rights" require self-sacrifice but facilitate group cohesion and cooperative living.

Campbell saw in all cultures a tension between values that benefit the group, and values that benefit the individual. Both were necessary but had to be kept in balance. The group values were taught, preached and enforced, while the individual values arose spontaneously. Campbell noted that it is unnecessary to advise people to look out for their own interests -- they figure those out for themselves pretty quickly.

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[4] Paul Johnson (Modern Times, Ch. 1) sees this as a unique 20th century phenomenon. Hannah Arendt traces the beginnings of this trend to the romantic philosophers of Europe in the early 19th century (The Origins of Totalitarianism, p. 168)

[5] Campbell, "On the Conflicts Between Biological and Social Evolution and Between Psychology and Moral Tradition."

As with all other cultures and societies, social values channel the actions of modern Americans. In all, six distinct sets of values influence American behavior, some dating back thousands of years, but others emerging as recently as the 1920s. Each set entered our cultural evolution during a unique period in history. If our times seem prone to values confusion, it may be because we persist in trying to live by all six sets of values, even though they often are incompatible or even contradictory, .

We can analyze and discuss values more clearly if we first distinguish among three types of values:

Official values: These are the values embodied in, or promoted by, the laws and institutions of a society or culture. Examples of America's official values are found in the Bill of Rights, the Pledge of Allegiance, the Ten Commandments, and the Boy Scout Oath.

Professed values: If you ask someone what values he believes in, he may give you a list similar to the official values of his society, but not necessarily. Public opinion surveys about values report professed values -- the values people say they believe in.

Operative values: People's actual behavior is guided by values that may be quite different from their society's official values, or even their own professed values. The former case may give rise to rebellion, and the latter case we call "hypocrisy" -- for example, someone espousing belief in motherhood and apple pie, then turning around and stealing an apple pie from somebody's mother.

Historians, philosophers, political scientists and school teachers tend to concentrate on "official values" -- the ones that social institutions embody and officially preach. These can be useful in comparing one society to another, but they are imperfect guides to why people really do things.

Survey researchers specialize in "professed values", often with attention-grabbing headlines: YUPPIES MORE MATERIALISTIC THAN THEIR PARENTS, and so forth. There are some problems with how surveys measure values, but even more important is that people often don't know, or won't admit, their true values. People's moment to moment behavior flows from their "operative" values, which may or may not correspond to their society's official values or to their own professed values.

A quick example illustrates the difference. Scientists have a code of "official values" -- honesty, objectivity, openness, the pursuit of truth and accurate knowledge, and so forth. A survey would verify that virtually all professional scientists profess these values. However, every now and then "operative values" such as ambition, pride, greed, power or fame have prompted scientists to fudge data or falsify results[6].

These distinctions will aid our understanding of the evolution of modern American values over the centuries. Since the "sustainable society" is predominantly an economic issue, we will pay special attention to values pertinent to day-to-day economic behavior, i.e., consumer decisions.

The Judaic / Pre-Christian Period

According to Scripture, the Ten Commandments, and the rest of the Torah, originated with Moses around 1200 B.C. Realistically, those values had been developing in the Middle East long before their codification, and continued to develop thereafter. For that reason, the first line of values development in Figure One has no definite starting point.

The Ten Commandments included several that spoke directly to econmic behavior: Thou shalt not steal, and Thou shalt not covet thy neighbor's goods. The Torah reflected myriad other values in addition to the Ten Commandments. The books of Exodus, Leviticus, Numbers and Deuteronomy list rules of proper conduct based on such values as justice, fairness, charity, cleanliness, chastity, family, observance of ritual and sacrifice, and respect for others' property.

The later "Wisdom Books" -- Proverbs, Ecclesiastes, Wisdom and Sirach -- also indicate values of the Hebrews. Moderation in pleasures and goods is advised. Honesty, wisdom, self-discipline and temperance are invoked repeatedly. Thrift and prudence are advocated; and pride, greed, gluttony and envy are counseled against. Sirach 29:23 advises us to be content. Sirach 30:7 warns us not to spoil our children. Proverbs 21:17 tells us that he who loves pleasure will suffer want. Ecclesiastes avers that pursuit of wealth, power, pleasure and good times is naught but a chase after wind.

These were the "official values" of the ancient Hebrews -- their laws, rules, and soundest advice. The Old Testament also reveals some "operative values" that guided ancient Hebrew actions. Power and shrewdness seem to have been highly valued. The importance of the individual, and of tribal loyalty, are evident. Apparently the Hebrews also had tendencies toward materialism, pride, avarice and self-indulgence. Those who enjoyed God's blessing prospered, and this was in fact the basis for Jehovah's Covenant with Abraham[7].

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[6] Broad and Wade, Betrayers of the Truth.

We are told that when the Hebrews followed God's rules they enjoyed peace and prosperity. But when the balance among their values shifted toward self-centeredness, God's wrath followed apace. The Old Testament recounts several times when the Hebrews strayed from their "official values," bringing Jehovah's punishment down upon them. Divinely inspired leaders eventually returned them to righteousness.

Thus the tension between individual values and group values described by Campbell, as well as the difference between official and operative values. The Old Testament may not be objectively or scientifically true in every detail, but it does expose the thoughts, beliefs and myths of a culture at the roots of modern American culture. Composed between two and three thousand years ago, it pertained to a small nation of several tribes. Their economy was agricultural, trade was local, and the primary sources of power and locomotion were people and beasts of burden. But although our modern technology and economy are vastly different from the ancient Hebrews', our human and social problems seem remarkably similar.

EARLY CHRISTIANITY / CATHOLICISM

Like other religions, Christianity did not simply appear but had its roots in prior religions and belief systems. Commonly portrayed as having emerged directly from Judaism, it bears influences from other Middle Eastern religions also. For our purposes there is no difficulty with using Jesus Christ as the origin of Christian values. Christianity has many values in common with Judaism, but significant differences are apparent. It emphasizes a dualistic, Apocalyptic struggle between good (God) and evil (Satan). It promises salvation and an afterlife. And it outright rejects materialistic values (e.g., "The love of money is the root of all evil" [8]). In His Sermon on the Mount[9], Jesus preached humility, charity, peace, sincerity, the integrity of the family, detachment from earthly concerns, and the supreme importance of salvation. He preached against selfishness, covetousness, sensuality, lustful passion and the desire for revenge and retaliation.

Judaism was the religion of the Chosen People, but Christ's message was universal. This marked the divergence of religious and cultural values and established spiritual equality as a new value[10]. The ancient Hebrews' religion was more or less congruent with their culture[11]; but members of any culture could choose to follow Christ's teachings. Christianity spread throughout the known world, and by the Middle Ages the influence of the Catholic church extended from Byzantium to every corner of Europe.

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[7] Genesis 15 - 22

[8] 1 Timothy 6:10

[9] Matthew 5, 6, 7

[10] Renan, The Life of Jesus, p. 379.

St. Thomas Aquinas codified Catholic values in Summa Theologica during the 13th century. He listed as virtues: faith, charity, hope, prudence, religion, fortitude and temperance. His seven capital sins were: pride, gluttony, lust, avarice, sloth, envy and anger, with pride (in the sense of making oneself the center and goal of everything else) at the top of the list because it was present in some manner in all sins.[12]

The "official values" of Christianity seem reasonably stable from the time of the New Testament to the Protestant Revolution. It would be difficult, however, to summarize the "operative values" of Christians during this period because so many different cultures and environments were encompassed. Sources such as Chaucer's Canterbury Tales, Dante's Inferno, and Boccaccio's Decameron, indicate that the day-to-day lives of people in Christian lands were steered by pretty much the same "operative values" as were the lives of the ancient Hebrews -- a mixture of St. Thomas's virtues and capital sins.

REFORMATION / PROTESTANTISM

Some time after the year 1000 A.D., a welter of changes began in European life, including:

Migration of wealth, a shift of prosperity from southern to northern Europe.

Political disintegration, as Europe ceased being unified under the Church and broke into a multitude of city-states.

The Black Plague, which coupled with war and famine reduced the total population of Western Europe by at least 50% and possibly as much as two-thirds during the years 1300 and 1450.[13]

Technological changes -- for example during the 15th century improved ship design, plus the development of firearms and moveable type printing, helped usher in the modern, Western-dominated world.

The scientific method, plus spreading literacy, greater availability of books, the rise of secular universities, and foreign travel and commerce, ended the role of the Church as gatekeeper to knowledge. Knowledge became available to any and all who might desire to exploit it.

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[11] Rubenstein, The Age of Triage.

[12] Cunningham, The Christian Life.

[13] Burns, Lerner and Meacham, Western Civilizations, p. 375.

The world was in flux, and changes in values inevitably followed. Martin Luther's Ninety-five Theses of 1517 is a convenient milepost for the beginning of Protestantism, but other reformers, for example Calvin and Zwingli, were also active. The various Protestant movements were staunchly Christian and emphasized a number of values in common, including: individualism, freedom, duty, moderation, responsibility, self-expression, good works, salvation and faith.

Calvinism played a key role in the evolution of American values. Taking their cues from the Old Testament, the Calvinists placed high value on virtuous living, humility, repentance and knowledge. Of particular interest is their belief in predestination -- one's salvation or lack thereof is settled regardless of his conduct on earth. The Calvinists resolved the anxiety this engendered by noting that those with Jehovah's blessing enjoyed prosperity. Labor being an absolute necessity, profit from labor must therefore be a sign of God's blessing. However, Calvinists were not to indulge themselves with their wealth, but rather should use it to help the less fortunate.

Weber posited that modern capitalism arose from the association of Calvinistic moral values with economic success[14]. An equally plausible interpretation[15] is that this package of values was selected because it reconciled Christianity with the newly revealed opportunities for accumulating wealth. It is probably no accident that this religion took hold in the rising commercial nations, Switzerland, Holland and England.

The Puritans who came to American shores in 1620, were of the same Calvinist sect that spawned Oliver Cromwell a few years later. The Puritans dominated New England for many decades, and Boorstin[16] makes a good case that Boston Puritans -- Yankee traders -- were instrumental in setting the tone for subsequent American trade and industry.

ENLIGHTENMENT / PRE-INDUSTRIALISM

By the late-1700s developing intellectual currents threatened the Protestant values dominant in America. Enlightenment philosophers -- Voltaire, Condorcet, Rosseau, Hume, Kant, Benjamin Franklin and Thomas Jefferson, among others -- sought a viable alternative to Christian faith and dogma. They turned for their inspiration to the Greek and Latin writers of classical antiquity and to the new scientific method.

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[14] Weber, The Protestant Ethic and the Spirit of Capitalism.

[15] e.g., Tawney, Religion and the Rise of Capitalism.

[16] Boorstin, The Americans: The National Experience.

Enlightenment thinkers favored freedom in all its forms.[17] Their ideas formed the "official" political values of the United States, as embodied in the Declaration of Independence, the Constitution and, especially, the Bill of Rights. The rights to life, liberty and (a first!) the pursuit of happiness were asserted. Religion was separated from political authority. Freedoms of speech, the press, assembly and religious expression were guaranteed.

Two Enlightment philosophers especially merit our attention. Adam Smith's theories are the bedrock of the modern American economy: They present an "official" justification for the values of self-interest and consumption. Jeremy Bentham, founder of "utilitarianism," made the first systematic effort to describe and evaluate human actions, institutions and laws in terms of pleasures and pains -- in other words, as to how they affected people, rather than on abstract principles of right and wrong. His ideas shaped first English, and then American, common law.

During the mid-1700s Benjamin Franklin (a founding father of American advertising) published his "Poor Richard's Almanac," which included a host of practical maxims proffered as wisdom. For example:

- He that chops his own wood is twice warmed.

- When prosperity was well mounted
  She let go the Bridle
  And soon came tumbling out of the saddle.

- The art of getting riches consists very much in thrift.

- Nothing buys more pain than too much pleasure.

- Who is rich? He that rejoices in his portion.

- Rather go to bed supperless than rise in debt.

An outstanding commercial success, Franklin counseled thrift, frugality, moderation and hard work. His "semi-official" admonitions echo the Old Testament, Montaigne and the Latin and Greek philosophers, and he freely admitted to gleaning his practical wisdom from many sources including those of antiquity. The important point here is that after nearly 3000 years, people were still being given the same advice, underlain by the same values. (And apparently with the same results: Franklin despaired of anyone actually following it.)

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[17] Gay, The Enlightenment: An Interpretation.

Thus "official values" at the time of our nation's founding were an admixture of ancient wisdom and modern, "scientific" thinking. A perceptive look at American pre-industrial "operative values" is found in Tocqueville's observations of America during the 1830s. He reported that Americans were strongly middle class, that the overriding value was equality (not freedom), and that the secret to the degree of liberty Americans enjoyed lay in the strong religious values by which they lived. He noted the strong family values in America[18], as well as values of mobility, progress, newness and novelty, practicality, education, courage (in commerce), chaste living, orderliness and accomplishment of practical purposes. He also observed:

> "I know of no country where the love of money has taken stronger hold upon the affection of man."[19]
>
> "In America the passion for physical well-being is not always exclusive, but it is general . . . Carefully to satisfy all, even the least wants of the body, and to provide the little conveniences of life, is uppermost in every mind."[20]
>
> "Democratic institutions have a strong tendency to promote the feeling of envy in the human heart."[21]
>
> "Equality suggests to men some very dangerous propensities. It tends to isolate them from each other, to concentrate every man's attention upon himself; and it lays open the soul to an inordinate love of material gratification."[22]
>
> "It is strange to see with what feverish ardor the Americans pursue their own welfare; and to watch the vague dread that constantly torments them lest they should not have chosen the shortest path which may lead to it."[23]

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[18] Adam Smith attributed America's fondness for children to the fact that unlike in Europe, a large family was an economic advantage in colonial America.

[19] Tocqueville, Democracy in America, p. 43.

[20] Ibid, p. 338.

[21] Ibid, p. 118.

[22] Ibid, p. 258.

[23] Ibid, p. 344.

The notion of "progress" originated during the Age of Enlightenment. This period represented perhaps the most decisive break from the values that preceded it. From the ancient Hebrews through the Protestant Revolution, the ultimate touchstone of "official" values was man's relationship with, and duty to, God. Borrowing from their counterparts of ancient Greece and Rome, the philosophers of the 18th century based their own "official values" on rational choice, assuming that free men's well-informed actions, based on enlightened self-interest, would automatically redound to the common best interests of all[24]. Thus the period of the Enlightenment saw morality cleave away from theology. One might say the Enlightenment period marked the moment at which men of the mind asserted that their wisdom was superior to God's.

INDUSTRIALISM

The Industrial Revolution had begun in Europe in the17th century, and by the 1840s Karl Marx was lamenting England's satanic factories. However, America lacked sufficient capital and surplus labor to support large scale industrialization until after the Civil War. Commerce played a small part in the lives of Americans of those times, with nearly three-quarters of families living on self-supporting farms[25]. With commerce moving slowly, and the citizenry largely self-sufficient, there was little incentive for mass production.

The railroads, beginning in the 1840s, soon led to the modern industrialized age. Following the Civil War the Horatio Alger books appeared. Eventually totalling more than 130, they instructed ambitous boys in the new values, stressing courage, self-discipline, sobriety, industriousness, dependability, honesty, application and risk-taking -- all aimed at attaining commercial success and the good life.

The YMCA and the Sunday school movements were organized during this same period, also to help inculcate industrial values in an agricultural nation. According to historian Douglass North[26], "Factory discipline (that is, rules and penalties to enforce behavior) had to be supplemented by investment in legitimating the new organizational forms. The Industrial Revolution was characterized by sustained efforts to develop new social and ethical norms," including hard work, saving, thrift and sobriety.

By the 1880s a national industrial infrastructure was in place, and values experienced a shift in emphasis. From that period to the end of

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[24] An assertion refuted by Garrett Hardin in his "Tragedy of the Commons." (in Daly, op. cit.)

[25] Norris, "Advertising History -- According to the Textbooks".

[26] North, Structure and Change in Economic History.

World War I, "managerial capitalism" took hold in the United States. The rapid expansion of American industrial corporations had created an entirely new class of employee -- the corporate manager[27].

During this latter phase of American industrialization several new vehicles for transmitting values appeared. Traditionally, values had been taught through family, church and the institutions of the immediate social group. However, the rise of large, anonymous cities and the concurrent demise of small, intimate rural communities demanded new mechanisms.

One was universal public education, to the secondary level, founded on Dewey's pragmatic values.[28] Another was the mass media. The third was the youth organization, for example Boy Scouts of America (founded in 1910). The Scout Oath states its objectives: duty to God and country, helping other people, and keeping oneself physically strong, mentally awake and morally straight. The Scout Law tells the scouts which values to follow: A scout is trustworthy, loyal, helpful, friendly, courteous, kind, obedient, cheerful, thrifty, brave, clean and reverent. Such guidance would have been unnecessary, even irrelevant, prior to industrialization and urbanization. But in our modern context, could someone looking to hire a middle manager ask for anything more ideal?

CONSUMERISM

Our present era of "consumerist" values began at the close of World War I. War-driven expansion had created productive capacity far in excess even of the burgeoning middle class's ability to consume.

Rather than brook plant closings, unemployment and post-war depression, the national solution was to expand consumer demand to match supply. Malcolm Cowley returned from Europe to discover that old values of industry, foresight and thrift had given way to a newer form of capitalism, which "did not need work and saving, but leisure and spending, not a producing but a consuming ethic." He commented on the singular boost that liberated intellectuals (i.e., Greenwich Village bohemians) contributed to this transition: "Its own devotion to pleasure and self-expression tallied with the consuming ethos. Bohemia proved to be the vanguard of the market. 'Living for the moment,' once a radical idea, promoted buying for pleasure; price and utility ceased to restrain."[29]

Historian David Potter agrees. But there was a problem:

"How can the consumer be educated to perform his role as a consumer,

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[27] Chandler, The Visible Hand.

[28] Boorstin, The Americans: The Democratic Experience.

[29] quoted in The Last Intellectuals by Russell Jacoby, p. 38.

> especially as a consumer of goods for which he feels no impulse or need? . . . The only institution which we have for instilling new needs, for training people to act as consumers, for altering men's values, and thus for hastening their adjustment to potential abundance, is advertising."[30]

The 1920s saw the advent of commercial broadcasting, as well as an expansion of magazine publishing. As Figure Two shows, advertising expenditures, which had exceeded the money spent on public education for decades, shot upwards after World War I.[31] They fell below education during the depths of the Depression and the curtailed consumption of World War II, but resumed their lead in the 1950s. Russia's Sputnik in 1957 finally provided sufficient urgency to push public education permanently ahead of corporate advertising budgets[32]. Widespread installment buying took hold in the 1920s: By 1929 one-fifth of all retail sales depended on credit[33]. The work ethic gave way to speculation, and leisure and recreation gained importance. Aided by motion pictures and jazz music, the expectation of "having fun" began to spread.

By the end of the Great Depression, consumerist values had become firmly incorporated into our "official" political values. Roosevelt's "four essential human freedoms" (sic) included some freedoms to (speech, expression and worship), but also two freedoms from: freedom from want, and freedom from fear. The Social Security Act was enacted in 1935: a perrenial "operative" value, security became an "official" American value.

Sociologist Robin Williams[34] used data from a number of sources to document values shifts in America. He found that values revolving about "work" and "achievement" peaked in the 1890s and have been declining ever since; and that values such as "practicality," "efficiency," "progress," and "freedom" have been slipping since 1945. On the other hand, the importances of "success," "enjoyment," "fun," "material comfort," "equality," and "conformity" have steadily increased since the turn of the century.

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[30] op. cit., p 175.

[31] On a per capita basis, and adjusted for inflation, advertising expenditures in 1920 were only slightly higher than in 1910, but were 18.5% higher in 1928 than in 1920. By 1960 per capita ad expenditures were 56% higher than in1920 in constant dollars, and by 1980, 100% higher.

[32] In no other modern, developed country (e.g., England, Germany) have advertising expenditures ever exceeded those on education.

[33] Perrett, America in the Twenties, p. 353.

[34] Williams, "Individual and Group Values."

AMERICAN VALUES IN THE 1980s

Tracking shifts in values is chancy: interpreting those shifts is more problematical yet. The crazy-quilt social fabric of modern-day America seems to have resulted from an extended evolution during which a welter of values rose, changed, metamorphosed and declined. The values time-lines in Figure One all stretch from their origins to the present time, and on into the future, because modern Americans persistent in trying to organize their lives according to all six different sets of values.

Much of what we consider to be "common decency" comes to us from the ancient Hebrews and no doubt antedates them. Christian values, both Catholic and Protestant, are promulgated to their memberships and celebrated in national holidays; and Judaism is practiced by millions. Our laws and political system rest on Enlightenment values, which mass media pundits and editorial writers champion enthusiastically[35]. Our schools continue to reflect the achievement-oriented values of the industrializing period during which they originated.

But in addition, modern America has a new set of "official" values, those of a consumption-based industrial system. Starting their ascent in the 1920s, these values represent as radical a deviation from "traditional" values as could be imagined. The advertising drumbeat marking the cadence of modern lives has flipped the virtues and the capital sins of St. Thomas Aquinas, one for the other. Incessant exhortations promote pride, avarice, gluttony, lust, envy and sloth[36], at the same time steering us relentlessly away from prudence, temperance and fortitude.

Human societies entail commonly accepted organizing principles, and values evolved over the centuries in answer the social demands of altered technological and economic conditions. Our "consumerist" values represent a logical step in the progress of Western Civilization. Reviewing the pattern that values changes have followed, it seems that "official values" have moved steadily over the past three centuries toward the "operative values" by which people from the times of the ancient Hebrews have always yearned to be guided -- be free of authority and have a good time. For that is the essence of the two core values on that underpin our modern consumer society: 1. Unconstrained freedom of choice; and 2. Universal consumer satisfaction.

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[35] The editorialists and commentators generally disregard the fact that apart from their own observations and exhortations (the portion of the press and television least attended to by media audiences), our mass media are the most forceful and effective promulgators of consumerist values.

[36] And in time of war, anger -- e.g., see Dower, War Without Mercy: Race and Power in the Pacific War, 1986.

It is possible that, for the first time in human history, Americans (and to an increasing extent, people in other developed countries) have reached a stage in social evolution at which the bulk can reasonably expect their lives to be pleasant ("satisfaction") and unfettered ("freedom of choice"). Very likely more Americans would endorse this view than would dispute it.

However, consumerist values may be an aberration. Many social critics fear this to be the case. It is entirely possible, as Donald Campbell contends, that traditional values reflect timeless wisdom on human interactions with one another and with the physical world. In other words, despite our intellectual and technological progress, there remains an essential human spirit and an essential human condition. Ernest Schumacher sharply criticized the values of the modern industrial world:

> "The current system is driven by the systematic cultivation of greed and envy, the very forces which drive men into conflict . . . The cultivation and expansion of needs is the antithesis of wisdom. It also is the antithesis of freedom and peace. . . In a sense the market place is the institutionalization of individuality and non-responsibility. Neither buyer nor seller is responsible for anything but himself. . . As a society we have no firm basis in any meta-economic values, and where there is no such belief the economic calculus takes over . . . To the extent that economic thinking (dominates), it takes the sacredness out of life, because there can be nothing sacred in something that has a price."[37]

Schumacher advocates a return to Christian values, and other commentators such as Richard Rubenstein, Paul Johnson and Alvin Toffler pin their hopes on a re-emergence of spiritual or traditional values. However, there is a difficulty: The world in which those values evolved is gone forever. This raises intriguing questions: Do values eventually evolve to provide an appropriate organizing system for a particular technological and economic milieu? Or, should the technology and economy of a society be designed and controlled to concide with some set of basic, human values?

If the first proposition is true, then it is just a matter of time (although perhaps several generations) before values fully evolve to match the needs of the modern, mass industrialized society. But if the second is true, then modern America is in big trouble, because for the past sixty-odd years we have been pushing a vast program to undermine and overthrow values that had pertained to Western Civilization for its entire recorded history.

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[37] p. 33 ff.

CONSUMERIST VALUES IN CONTEMPORARY AMERICA

Consumerist values now pervade American life at all levels. The original impetus behind consumerist values was to stimulate economic demand. Many involved felt they were performing a valuable service by helping make "the good life" available to more people. Marketers today believe their work benefits the American public and beyond that, the entire world. A recent motto of the American Marketing Association expresses it succinctly: "Celebrate Marketing -- It Makes A Good Life Better."[38]

Few are opposed to free choice and satisfaction. With the slick skills of advertising behind them, consumerist values quickly permeated the marketplace and spread beyond it, creating a social order in which, as Ivan Illych pointed out, the priest has been replaced by the economist. Perhaps God was demoted because in spite of the rules He imposed on us, He could not guarantee satisfaction.

Politicians embraced the new values quickly and enthusiastically. Calvin Coolidge's response to an agricultural crisis in the 1920s was that farmers should take up religion.[39] Scarcely a decade later Franklin D. Roosevelt proclaimed the government's obligation to insure a minimal degree of material well-being. In the aftermath of World War II our foreign policy assumed the mission of spreading the good life abroad.[40] During the 1960s the Johnson administration resolved, with its Great Society program, to rid the nation of poverty.

The right to pursue happiness metamorphosed into the right to experience happiness. The nation now is rife with citizens and special interest groups who expect the government (i.e., other taxpayers) to underwrite their personal prosperity. Our legal system has followed the same track. In the face of dissolving moral agreement, questions of proper behavior seek resolution in the courtroom. Increasingly, legal decisions hinge not on "rights" and "wrongs," but on consumerist values: Is it "unconstitutional" (i.e., does it impinge on some mandated freedom)? And is it "unsafe" or "unhealthy" (i.e., might it unjustifiably threaten satisfaction)?

Consumerist values infiltrate the workplace. Many expect their jobs to be easy, enjoyable, entertaining, remunerative and fulfilling -- a package touted as "Quality of Working Life." Consumerist values likewise impinge on the age-old institution of the family. Marriage and parenthood are promoted as sources of "satisfaction", and "choices" of the partners are much discussed. But as our sky-high divorce rate indicates, wedded bliss for many couples is less satisfying than expected, and their freedom to demand a product recall is unquestioned. Accomodatively, our legal and social institutions have eased dissolution of the family unit.[41] A poignant consequence is the legion of American children raised in broken homes.

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[38] Marketing News, February 15, 1988.

[39] Johnson, Modern Times, p. 245.

[40] e.g., see Isaacson and Thomas, The Wise Men; Potter, People of Plenty.

The transmission of consumerist values is pervasive. The role of advertising in indoctrinating American children to the consumption ethic by is obvious: In recent years media advertising expenditures have exceeded $100 billion annually. But consumerist values also are spread in subtle ways that many overlook. In past eras values were taught by family, church and community, primarily by training and example. Consumerist values now are inculcated by television, by public schools, and by third party child-care providers such as baby-sitters, day-care centers and preschools.

Parents plant the kids in front of the tube while they attend to their own needs, leaving our future citizens soaking up programs designed to interest and please them. Colorful, fast-action programs persuade them that (1) what they want is important; and (2) "good guys" like themselves deserve happy endings. Finely-crafted commercials drench their minds with promises of passive satisfactions[42].

In bygone years, a child in trouble at school met worse trouble at home. But many school administrators and teachers have discovered that in the Age of the Consumer, their own survival depends on keeping the children entertained and avoiding trouble-provoking demands. "Excessive" discipline may bring irate parents (or the ACLU) to their office doors. The right to wear gold chains and punk hairstyles overrides the responsibility to learn.

The majority of mothers are now in the workplace. Many children therefore spend the each week's working hours under the supervision of professional child-care providers, hired by a mother usually either in search of personal fulfillment, or (more likely) trying to earn enough money to maintain a desired level of consumption. Dependent on these revenues, providers are motivated to cater to their charges if they want to keep the business. American families even employ Santa Claus to help enforce family discipline through consumption. Children are assured that misbehavior will result in withholding of consumer goods by the jolly old spirit of Christmas.

Thus our children learn in many ways, even before they can talk, that the world is there to give them what they want, and that what they should want is consumer goods. Previously, values-transmitting institutions taught a society's children the commonly agreed rights and wrongs, whether the children liked it or not. This prepared them for assuming the duties and responsibilties of adult life. Our modern approaches prepare our children for American adulthood, but in different ways from what we might intend or expect. Irrespective of what we formally tell them, what children learn is that adults do what they want (i.e., freedom) and that they themselves should expect strangers to cater to them (i.e., satisfaction). And so we pass on to future generations the values of "the satisfied customer." History's first huge and powerful society predicated on mass self-indulgence, we impart to our children the values needed for following in our footsteps.

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[41] Like many other facets of the consumer age, it was during the 1920s that the emphasis in courts shifted from keeping families together, to facilitating their dissolution.

[42] Professor Neil Postman of New York University has estimated that the typical American child has put spent more than 5,000 hours watching television before he or she reaches school age. Only sleeping has occupied more of the child's time.

In The Closing Circle Barry Commoner pointed out how modern technology has upset the natural system, a product of millions of years of biological evolution. This happened because new, foreign materials were introduced into the physical environment, which had no natural mechanisms for coping with them. Analogously, modern technology may have introduced pollution into the social environment, also the product of a long period of evolution, and also having no mechanisms for coping with it.

Environmentalists warn that the human race faces a bleak future if steps are not taken to arrest environmental degradation. They call for vast changes in our lifestyle to slow the spread of pollutants, toxins and waste. Might a similar fate await us from social degredation, the result of values pollution? In any case, there is certainly no harm in pondering this question: What kind of future lies ahead for a society that indoctrinates its children with a system of values that above all leaves them expecting to be satisfied customers?

VALUES AND THE SUSTAINABLE SOCIETY

People who exhort us toward sustainability tend to advocate its institution through democratic, free choice of the public. Few if any advocate authoritarian or draconian measures. This is politically appropriate, given the philosophies that dominate contemporary intellectual discourse -- i.e., the prestige newsmedia, the universities and opinion-shaping journals. The typical conclusion is that we need more, and better, "education" -- i.e., our role is to gently persuade, not to indoctrinate.

These may be false hopes, since no society in recorded history has succeeded through democratic choices based purely on enlightened self-interest of individual citizens. Certainly our present society doesn't operate that way. But consumerist values enjoy decisive advantages over traditional or more "enlightened" values. They are a much easier sell, since other values demand self-denial, effort and subordination of one's own desires. And the commercial advertising media that promulgate them are much more popular than are churches and schools. Thus these values have become the only ones on which Americans can reach consensus. Our future citizens are indoctrinated, but by default we have turned that critical task over to marketing interests.

If we are to attain a sustainable society through democratic means, it seems that the American public must be broadly and comprehensively re-indoctrinated with values of self-sacrifice, frugality, moderation, and duty, a task that will take generations. Our current emphasis on maximizing freedom of choice and satisfaction can not lead us in that direction. The vast majority of citizens happily subscribe to these values, but at the most vulgar level. They gravitate toward the versions of Enlightenment values taught by television, not the versions advanced by wise and virtuous people like ourselves. Madison Avenue and Hollywood, not Kant and Hume, provide their models.

Here is the potentially unpopular message. It appears that democratic achievement of a sustainable society implies, realistically, a widespread and determined commitment to reinstituting conformity, self-denial, sense of duty and respect for authority. The goal would be to instill the internal controls necessary for a sustainable system that permits individual liberty.

This would dictate a constriction, not an expansion, of personal freedom; and it would require a lowering, not a heightening, of personal aspirations, dreams and expectations. Public service media messages will be worthless in achieving this, as they would be competing with ads for shiny cars, tasty treats and vacation cruises. Editorials, lectures and exhortations by politicians and intellectuals would be ineffectual in reaching the broad public, since the majority of Americans routinely ignores these[43]. Lester Brown suggests seeking the aid of church leaders in spreading the values of sustainability.[44] This would help, but an equally effective path may be to help religious organizations in spreading their values.

Since time immemorial the most effective ways of inculcating values have been mechanisms that shape children's minds. At present, the influence of commercial television is dominant, and marketing interests will not likely abandon their prerogatives. If we are serious about attaining a sustainable society, it appears that counter-measures such as the following might help:

- Sanctions against certain forms of expression, in particular that which glamourizes willful, self-indulgent or anti-authoritarian behavior (similarly to how sanctions currently operate against,

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[43] However, these channels could be important in legitimating the new emphasis among their own participants and audiences.

[44] Brown, op. cit., chapters 12 and 13.

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e.g., "male-chauvinist" expression).

- Religious training starting in infancy and continuing in the schools (which religions wouldn't matter decisively -- the important thing is that exposure to religious values should be pervasive and to the greatest extent possible, non-voluntary).
- Firm and consistent enforcement of disciplines such as dress codes, etiquette, anti-littering, etc. (such pressures now are being exhibited, for example, toward smokers).
- Programs of meaningful social service for youths, beginning in early school years and broadly supported.
- Intolerance of anti-social or self-indulgent lifestyles.

Such a program would require a consensus on ends and means that may not truly exist in America. Evidence exists of vast values gaps between our educated elite and the middle-Americans who shop in the K-Marts[45]. This list may strike some as "dull", "boring," "square," "middle-American," "conformist", "50s-ish," "Republican," "Bible Belt," or even "fascist." But before discarding these suggestions out of hand, think hard about how sincerely you desire a sustainable society. Their lifestyle may seem unexciting and repressive to some, but the Amish have kept one going for centuries. What other enduring examples come to mind?

The choice ultimately may come to a hard landing versus a soft landing, this being the soft one. Programs to emphasize traditional values could condition the day-to-day and moment-to-moment behavior of the mass of people away from waste and consumption, and toward a more conserving and ecologically sound way of life. Many Americans already struggle to maintain traditional values against the determined pressures of our consumption-ridden environment. They are friends of the sustainable society, not enemies; and they need the active support of those who support that goal.

Suppose that physical, economic and/or ecological limits finally intrude themselves forcefully on a mass society of self-indulgent people conditioned from birth to be satisfied customers. The alternative could be far more draconian, constrictive and unpleasant than what I have described. Public reactions to gasoline shortages during the 1970s provide a mild hint of the possibilities. If the threat of the greenhouse effect is real[46], or if deteriorating economic trends precipitate a national crisis[47], harsher constraints than those discussed here may be imposed, by people far less liberal-minded than we. As a worst case, if effective steps are not taken toward creating a world sustainable for human beings, nature may fashion a world sustainable for rats, roaches and crabgrass. Forceful actions toward re-emphasizing traditional values could help prevent this.

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[45] e.g., see Goldman, Reflections on America.

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[46] e.g., "Greenhouse America," Scientific American, January 1989, p. 20.
[47] e.g., Peterson, "The Morning After".

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FIGURE ONE

Major Periods in the Development of American Consumer Values

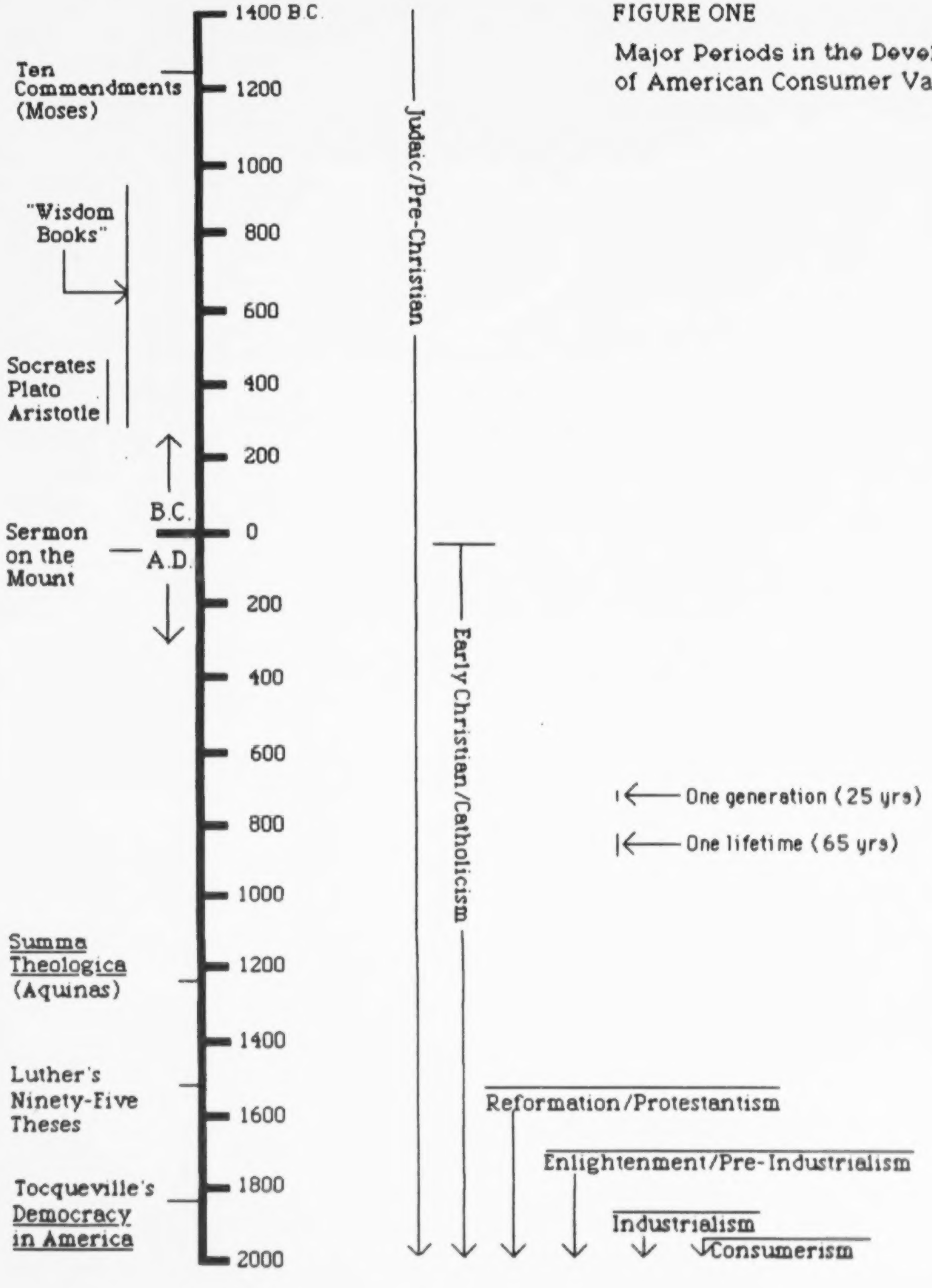
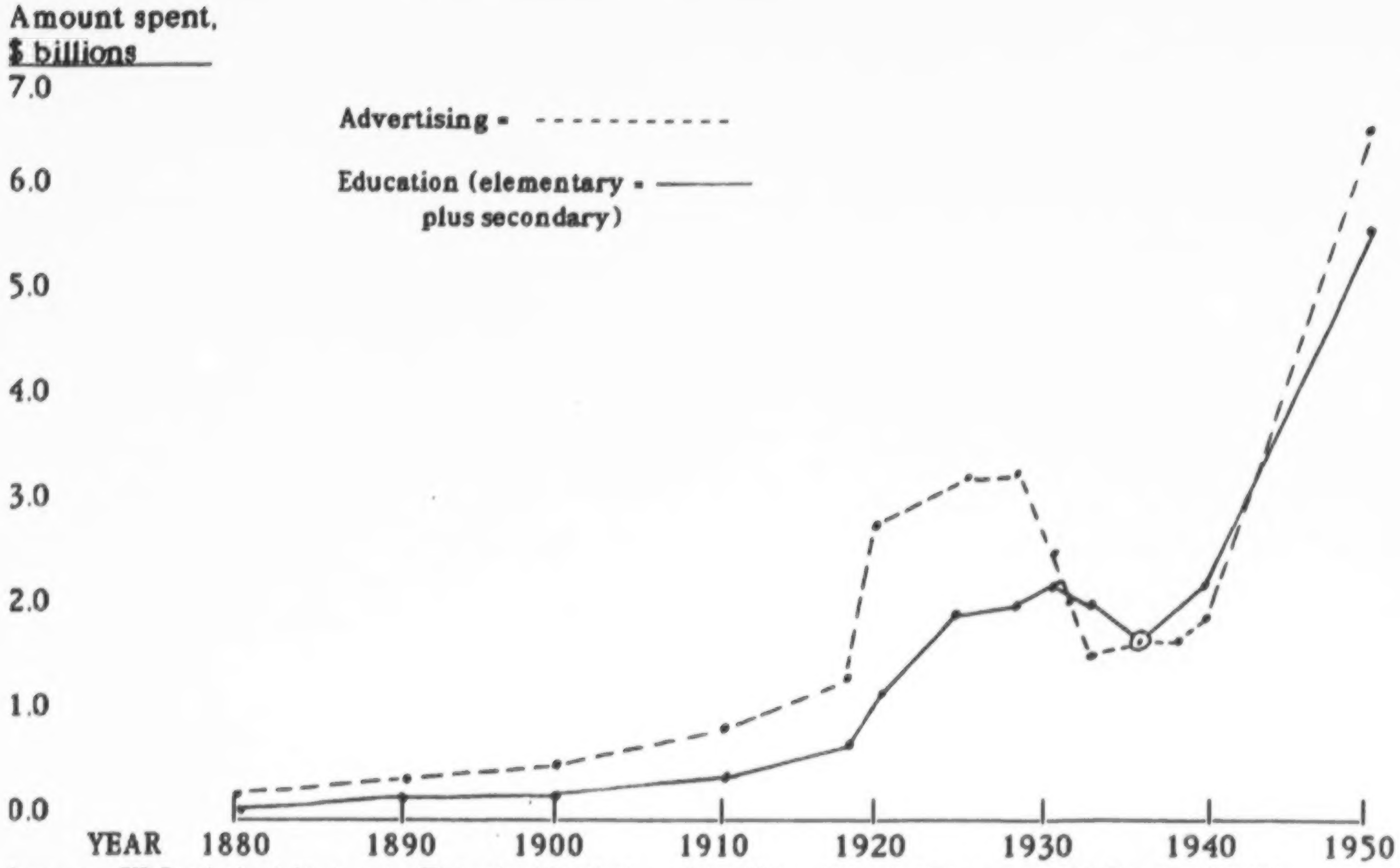

1400 B.C.
Ten Commandments (Moses)
1200
1000
"Wisdom Books"
800
600
Socrates
Plato
Aristotle
400
200
B.C.
0
Sermon on the Mount
A.D.
200
400
600
800
1000
Summa Theologica (Aquinas)
1200
1400
Luther's Ninety-Five Theses
1600
Tocqueville's Democracy in America
1800
2000
Judaic/Pre-Christian
Early Christian/Catholicism
Reformation/Protestantism
Enlightenment/Pre-Industrialism
Industrialism
Consumerism
One generation (25 yrs)
One lifetime (65 yrs)

FIGURE TWO

EXPENDITURES ON ADVERTISING AND PUBLIC EDUCATION IN THE UNITED STATES, 1880 TO 1950



Sources: US Statistical Abstracts; Historical Statistics of the U.S.-- Colonial Times to 1970; Borden (1942)

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AFTERWORD

NEW CHALLENGES FOR SCIENCE, TECHNOLOGY, AND SOCIETY EDUCATION

Leonard Waks

Science, Technology and Society (STS) is a rapidly expanding field of study at both school and college levels in the United States, Canada, Western Europe, Australia, New Zealand, and South America. Generated by concerns about nuclear weapons, environmental security and an "out-of-control" technology, the STS movement sprouted on university campuses in the 1960s and 1970s and spread to the schools in the 1980s. After a period of spontaneous grassroots development, during which it took a variety of forms, STS is now in a consolidation phase. There is throughout the movement a convergence on goals and curriculum practices (Waks, 1987).

In this paper I will begin with some remarks about the origins, goals, and methods of STS education, and then point to the challenges it now confronts.

The Origins of STS Education

The Western world has enjoyed a passionate love affair with technology since the industrial revolution. To an extent difficult to appreciate without conscious effort and historical study, our ideologies, the organization of knowledge, personal lifestyles, and moral sentiments, have all been re-shaped by the industrial mode of production. But in the 1950s and 1960s, this love affair entered a difficult period. Works by such "outside the system" intellectuals as Jacques Ellul, Rachel Carson, and Buckminster Fuller began a process of increasing awareness of the environmental, ethical, and quality of life issues arising from the global industrial enterprise. Nuclear weapons and the arms race intensified anxieties about our scientific-technical culture. Many ordinary citizens, lacking a scientific education, became intuitively aware that they lacked the knowledge to grasp public issues, that public affairs were increasingly controlled by elites whose power depended upon a virtual monopoly of scientific understanding. Many citizens, especially youth, directed feelings of fear and frustration against symbols of technological excess.

Similar sentiments found expression in an influential body of intellectual writing (still outside the academic mainstream) in the early 1970s that challenged the materialist values of industrial civilization, and looked forward to a "slow growth," "equilibrium" or "sustainable" society guided by more personal, ethical and ecological values. Important works included The Club of Rome report on The Limits To Growth, E.F. Schumacher's Small is Beautiful, Ivan Illich's Tools for Conviviality, and Robert Heilbroner's Inquiry into the Human Prospect and Business Civilization in Decline. Such works in turn influenced popular consciousness and discipline-based intellectual discourse.

The same sentiments also found expression in the student revolts of the late 1960s and early 1970s in North America and Europe, directed against the Vietnam War and the scientific-technical cultural milieu associated with it. Napalm became an emotionally-charged symbol of the excesses of technological civilization. On the edges of the campuses, students experimented with new life and learning styles. New ideological frameworks generated within Freudian and Marxian traditions inspired utopian visions of freer, more just, and more erotically pleasurable ways of living.

On many campuses, committees of humanists, social and natural scientists, and engineers formed to discuss new critical ideas about science and technology in society. These committees generated the first wave of multi-disciplinary courses in science and technology studies, inspired in many cases by the utopian visions and experiments in living brought in from the edge of the campus. Right from the start, some participants were concerned that if these science, technology, and society studies became established within business-as-usual academic routines, they would lose their utopian, critical, and experimental bite.

From the mid 1970s through the 1980s, STS has spread from the colleges and universities to the secondary schools throughout the United States, Canada, Great Britain, and Western Europe. Educational developments have paralleled the dialectical unfolding of environment and technology consciousness in the political sphere.

The first STS efforts were grassroots programs with an anti-technocracy "thesis," put forth by educators of a "liberal" or "left" orientation, concerned about environmental pollution, world hunger, and nuclear war. These concerns were reflected in the priorities of the Carter administration in the U.S. and its Global 2000 Report.

The 1980s have witnessed the ascendency of "conservative" leaders such as Reagan, Kohl, and Thatcher. World trade, economic competitiveness, and rapid technological development have dominated the agenda in this "antithesis" period, brushing aside concerns about environmental protection and economic justice. In secondary and higher education, the primary goals of STS studies broadened from technology criticism and environmental awareness to "technological literacy," broad understanding of the scientific and technical bases of contemporary economic and social processes. In this interim period, science, technology and society studies became organized as mainstream academic enterprises (e.g. philosophy of technology; environmental ethics) with increasing scholarly sophistication and academic respectibility; degree programs, scholarly societies, meetings, and periodicals have formed and in some cases even flourished.

The current period is one of "synthesis." Prime Minister Thatcher now holds compulsory environmental education seminars for her cabinet. President Bush declares himself to be the "Environmental President." The World Bank establishes an environmental division. The Green party displays surprising strength in the elections for the European Parliament. Everyone, whether left or right, deplores the Brazilian deforestation, worries about the greenhouse effect and the ozone layer, and grasps that economic development must now be accomodated to ecological limits. But few have yet confronted the implications of this new situation for productive processes, social organization and the shaping of individual lives, ideology, and popular values, and hence educational formats and routines.

Goals and Curriculum Organization in STS Education

Our late industrial era is dominated by many technology-related social issues. Examples include the control of nuclear weapons, the construction of a strategic defense in space, the control of genetically engineered organisms, chemical pollution and environmental security, resource depletion, and many others. STS education aims to promote scientific and technological literacy in order to empower citizen participation in democratic decision making and citizen action processes for resolving these issues.

STS education units, whether inserted in science, technology and engineering, and social studies classes, or packaged together in separate STS courses, frequently involve five phases:

(1) efforts to encourage attitudes of personal responsibility for the natural environment and the quality of life;

(2) awareness and investigation of specific STS issues, focused on both the scientific and technical content and the impact of given technological options on the well-being of individuals and the common good;

(3) decision making about these options, taking into account relevant scientific, technical, ethical, economic, and political factors;

(4) responsible individual and social action to carry the

study and decision-making forward into practice, often in cooperation with groups based in the community (e.g. "science shops," environmental groups); and

(5) abstraction from specific STS issues to broader considerations of theory and principle, including the "systems" nature of technologies and their environmental and social impacts, the policy-making process of modern technological democracies, and ethical principles which may guide life style and political decisions on technological developments.

Elsewhere I have termed this progression of phases the "responsibility cycle" (Waks, 1988a). These five elements conform closely to the five components of moral and value education derived from a philosophical analysis (Wilson *et al.*, 1968). It may also be said that STS education in its current form represents the adjustment of such a concept to the institutional constraints of contemporary schools and colleges. Programs of teaching and learning in STS may in the coming years emerge that are very different in the concrete details of their processes and objectives from typical units and courses of today, but that continue to include these five conceptually distinct elements.

The New Challenges for STS Education

STS educators have succeeded in developing an educational innovation and initiating its implementation. But beyond the mere insertion of STS lessons in the schools and colleges as we know them today, what are the long term goals of STS education?

It will help to remember that current educational practices are a product of the industrial era, not merely the extension of a pre-existing cultural form, "education," to masses of people. Mass education is hardly continuous with Plato's Academy, medieval Oxford and colonial Harvard. It is a new cultural form, providing for the socialization of competence, attitudes, and values for life in industrial society. The goals of mass education during the last hundred years have been shaped by the industrial division of labor and the material values of the industrial era. Children and youth have learned in schools to adjust their perceptions, thinking processes, emotions, aspirations and behavior patterns to the demands of industrial production and modern urban life.

The broad ethical goals of the education system were "dependent variables"; they were "built in," not derived autonomously by educators and learners. Values and plans of life shaped by educational interventions were determined by the structure of industrial society, which was in essential features the same wherever it developed. Education prepared young people for industrial production and for the consumption of industrially produced goods and services -- and industrially produced ideas as well. More years in school became increasingly equated with higher positions in the social hierarchy of industrial society, and an income to match -- an income convertable into high-tech, high-energy goods and services (e.g. central heat and air conditioning, automobiles, consumer electronic appliances, agri-business produce, hospital-based medical care). Prior cultural forms and guidelines for living were eclipsed, and cultural diversity was replaced by a uniform technological culture. It is difficult to over-state the central role of the system of schools and colleges in promoting and maintaining this culture.

But the culture of industrialism now finds itself challenged. Nuclear weapons and environmental pollution from the global industrial enterprise threaten the very structure of life on earth.

However, despite new "green" sounding slogans, the industrial and political elites have not yet proven themselves capable of responding effectively to this challenge. It has been easier for political leaders to yield to pressures from the military and industrial sectors, permit environmentally and humanly degrading practices, and try to hide the damage from a technologically illiterate population, than to confront the situation directly. Recent revelations about the contamination produced by the U.S. Department of Energy nuclear facility at Fernal, Ohio, provide a useful illustration.

In democratic societies an effective response to such problems requires a critical mass of citizens from all classes and groups to become aware, attentive, informed, and politically involved. There must be an effective challenge to contemporary culturally determined values and life style choices, and an awareness of the new ethical dilemmas facing humankind, followed by individual and socio)political action to address those problems the elites have thus far been unable to confront (Waks, 1988b).

To acomplish this goal will require a thorough transformation of the social instrumentalities of the industrial era, including the system of schools and the communications media, to serve the new needs of humanity. If this challenge were not daunting enough, in the U.S. it is made still more difficult by the growing proportion of disadvantaged and alienated youth who must be recruited effectively to become "part of the solution" (Waks, 1989b).

But it would be a profound error to think that educational and communications media are neutral, a-historic, merely technical "forms" that can be filled with any "content" we wish. The fifty)minute lesson in post-industrial values is still a fifty)minute lesson, bounded by the clock, and under the direction of a teacher serving as "foreman" for the "alienated" labor of learning. Courses in ethics and values in science, engineering and business are frankly "drops in the bucket" in curricula geared as a whole for industrial output and undertaken by individual students to maximize their income opportunities (Mayer, 1988, provides an insightful study of the impact of these courses). Regardless of their content, current educational means remain forms of socialization for industrial society.

My colleague Ivan Illich focused the issue clearly when he wrote in Tools for Conviviality that that people must learn to live within bounds but "cannot be taught." He added:

> It does not matter what the teacher teaches so long as the pupil has to attend hundreds of hours of age-specific assemblies to engage in a routine decreed by the curriculum and is graded on his ability to submit to it...(p.62) It is impossible to teach joyful renunciation in a world totally structrured for higher output (p.65).

People can become responsible, he concluded, only by "living active and responsible lives" (p.65).

The fundamental questions for STS education in the late industrial era are these:

(1) Can STS education play a significant role in a long*term social process leading to frugal, active, responsible and self-directed lives in democratically organized societies in a more economically just and environmentally secure future world?

(2) Can its current curriculum formats and routines advance this goal?

(3) To the extent that they cannot, what educational forms can, and how do we get there from here (Waks, 1988a)?

To these questions I can hardly offer definitive answers. It is a beginning to know what the questions are. Until clear answers are found, those of us in STS education must, to use Rilke's phrase, "live the questions."

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